SOIL MECHANIC 2

Kuat Geser Tanah (2)

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Pengujian parameter kuat geser tanah

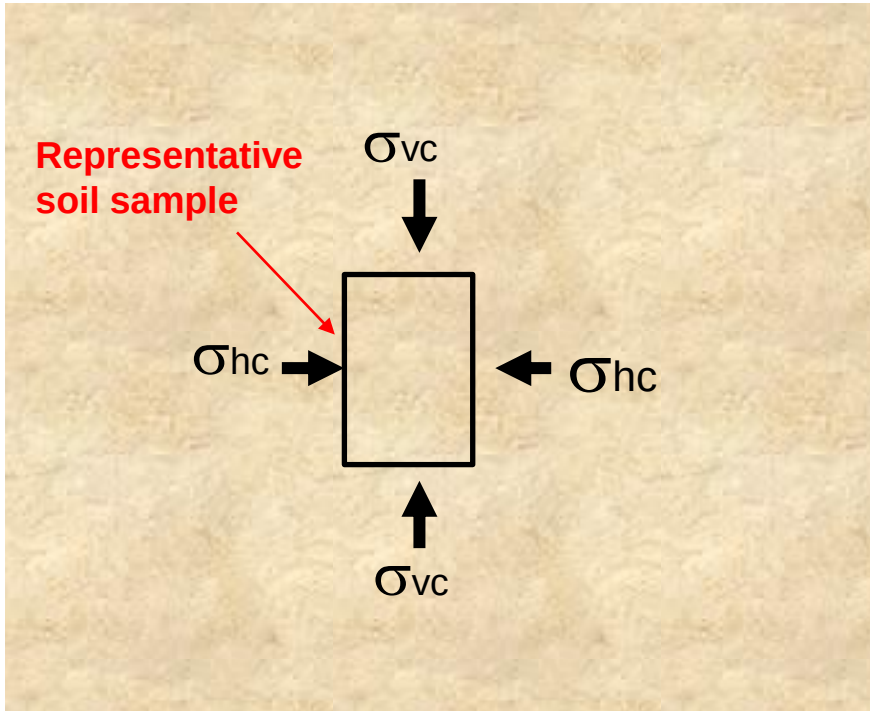
Pengujian Laboratorium

1. Uji Geser Langsung (Direct Shear Test)
2. Uji Triaxial (Triaxial Test)
3. Uji Kuat Tekan Bebas (Unconfined Compressive Strength Test)

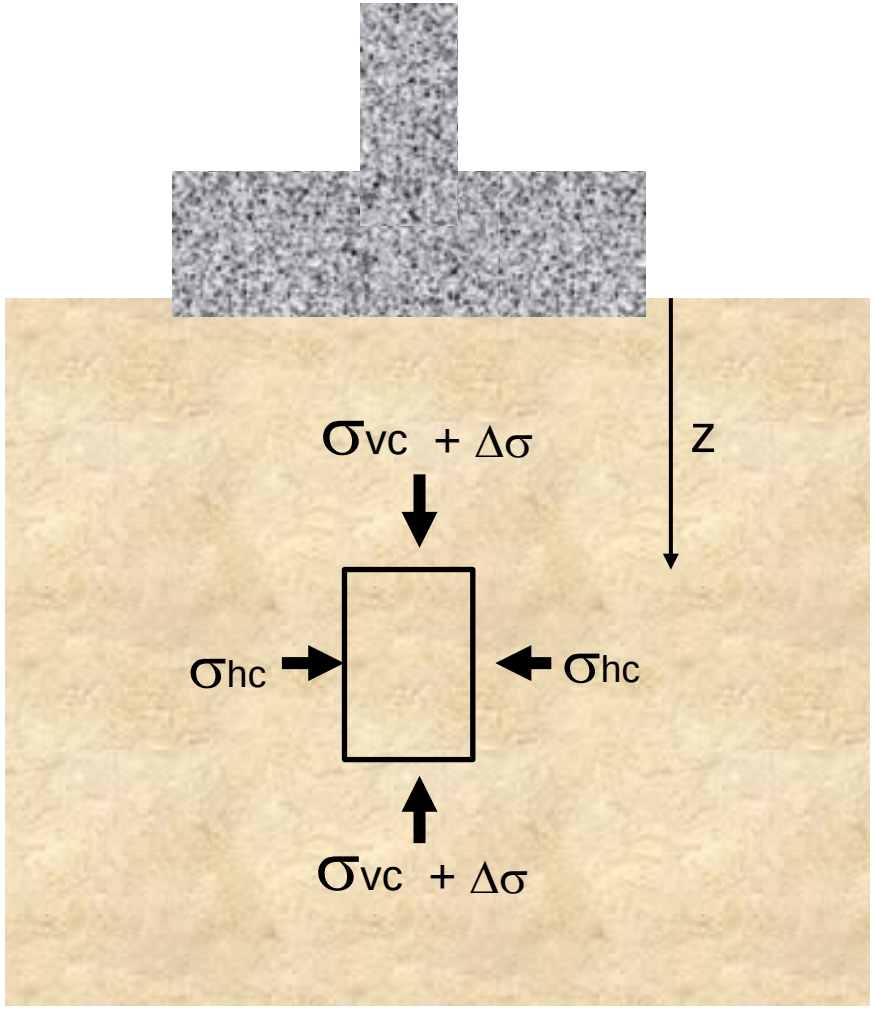
Pengujian Lapangan

1. Uji Vane shear
2. Pressure Meter

Laboratory Test



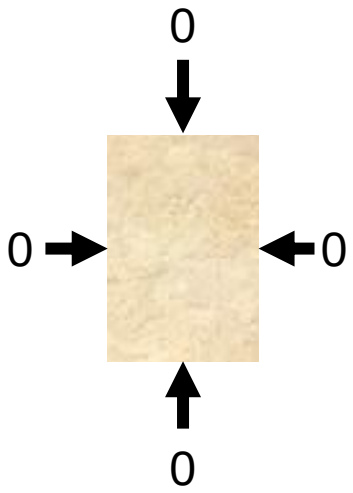
Before Construction



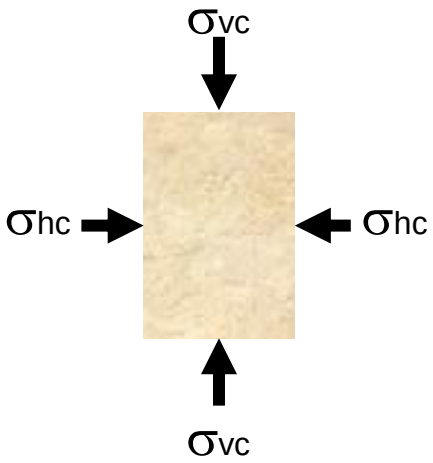
After and during Construction

Laboratory Test

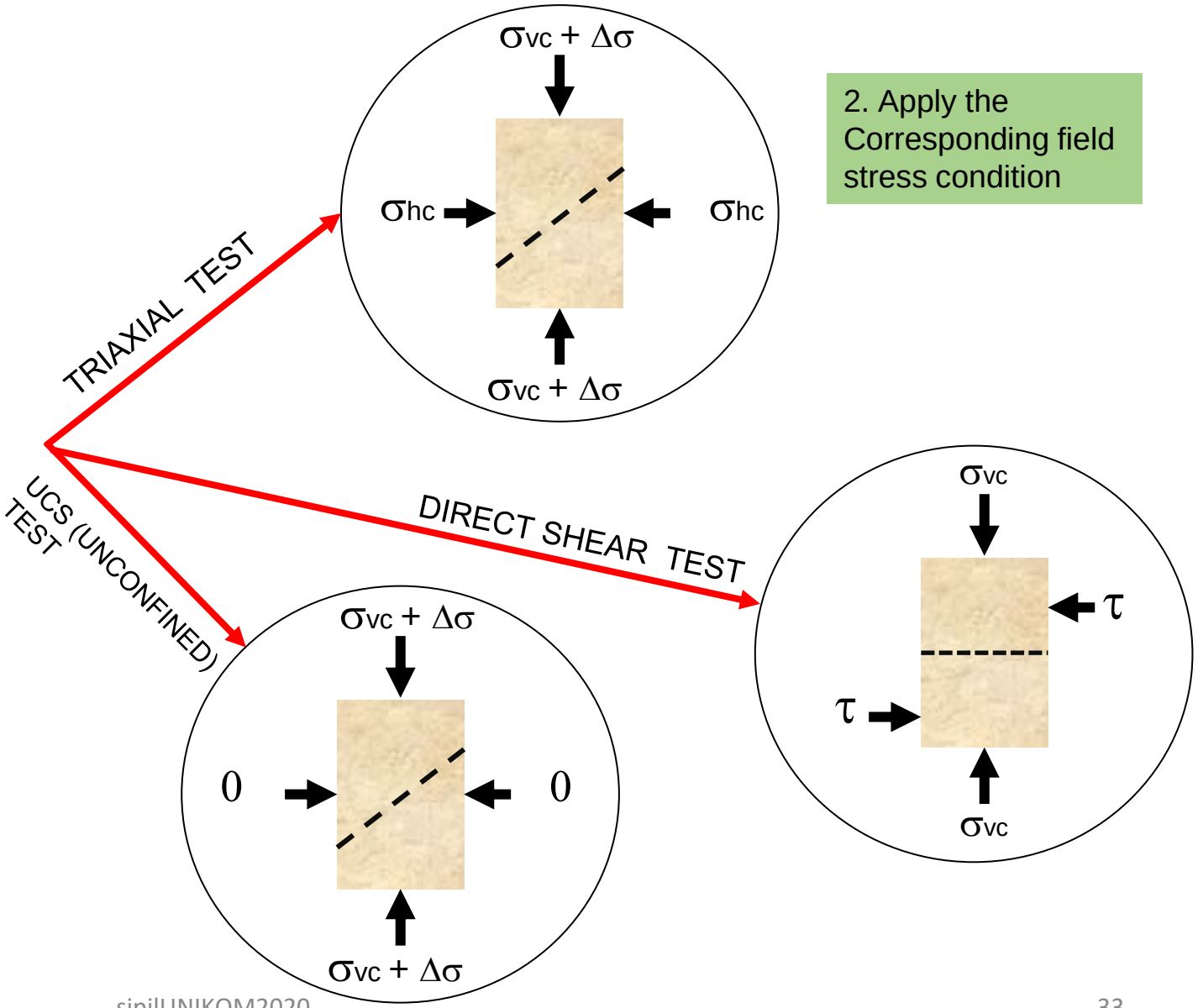
Simulating Field Condition in the Laboratory



Representative soil sample taken from the site

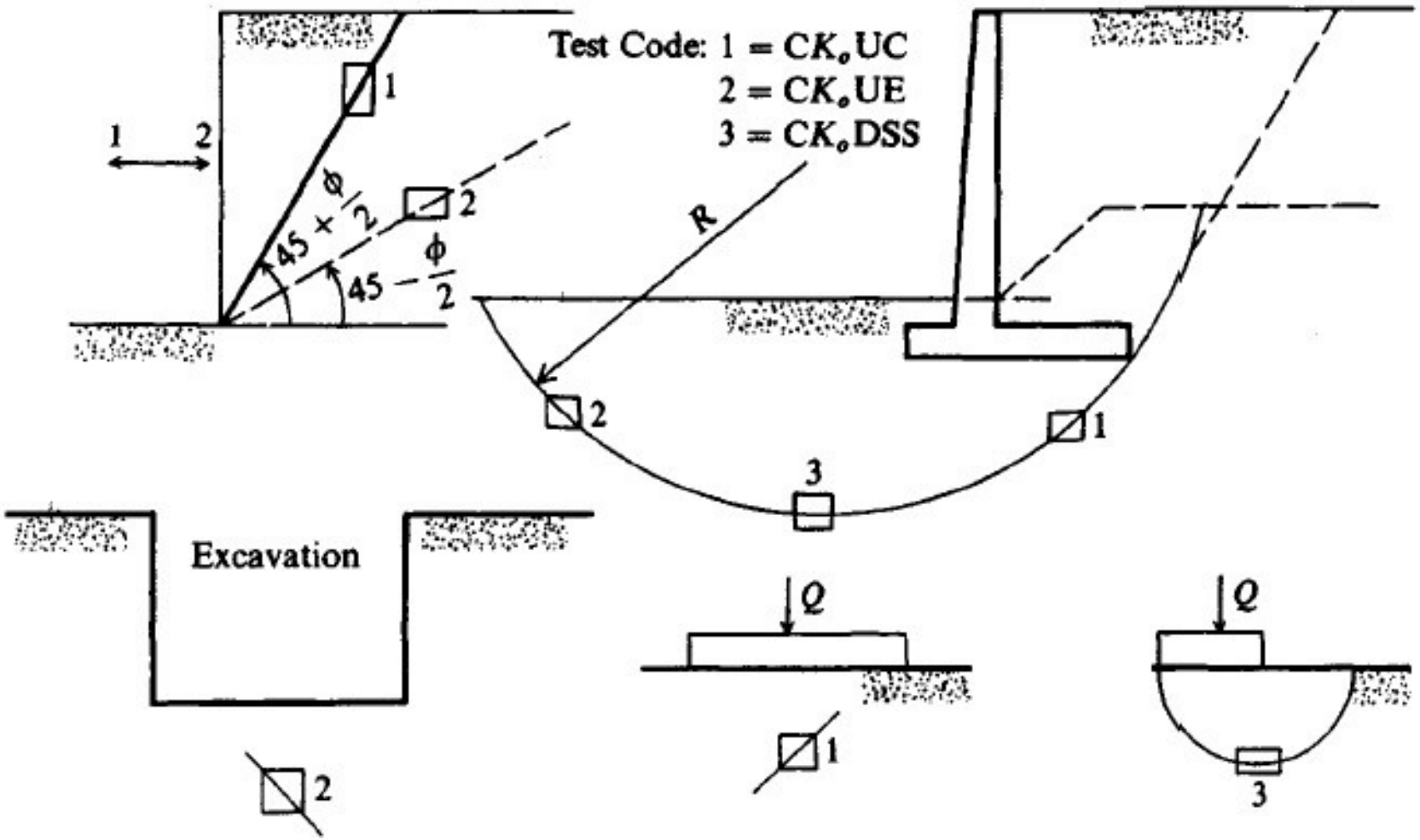


1. Set the specimen In the apparatus and apply the initial Stress condition

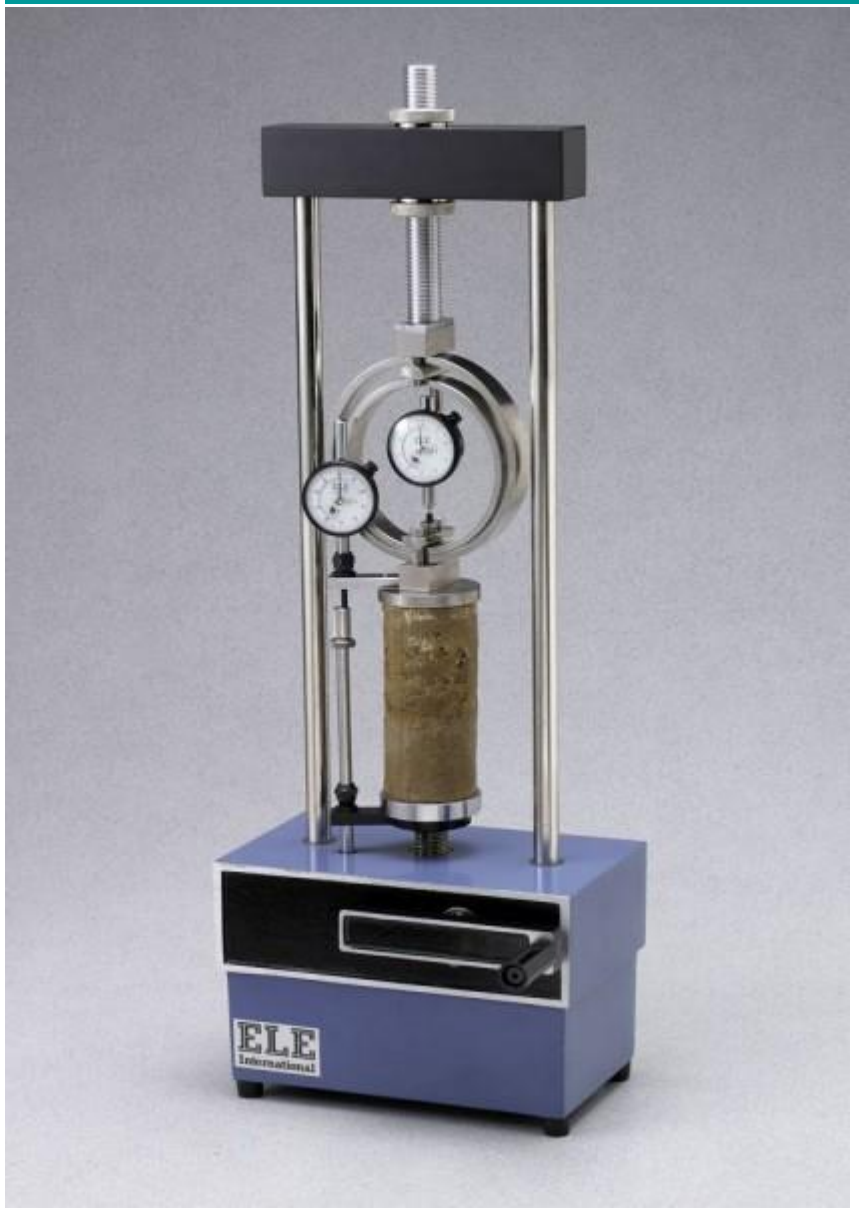


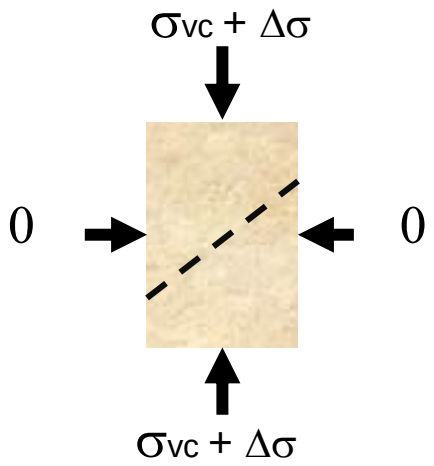
2. Apply the Corresponding field stress condition

Aplikasi

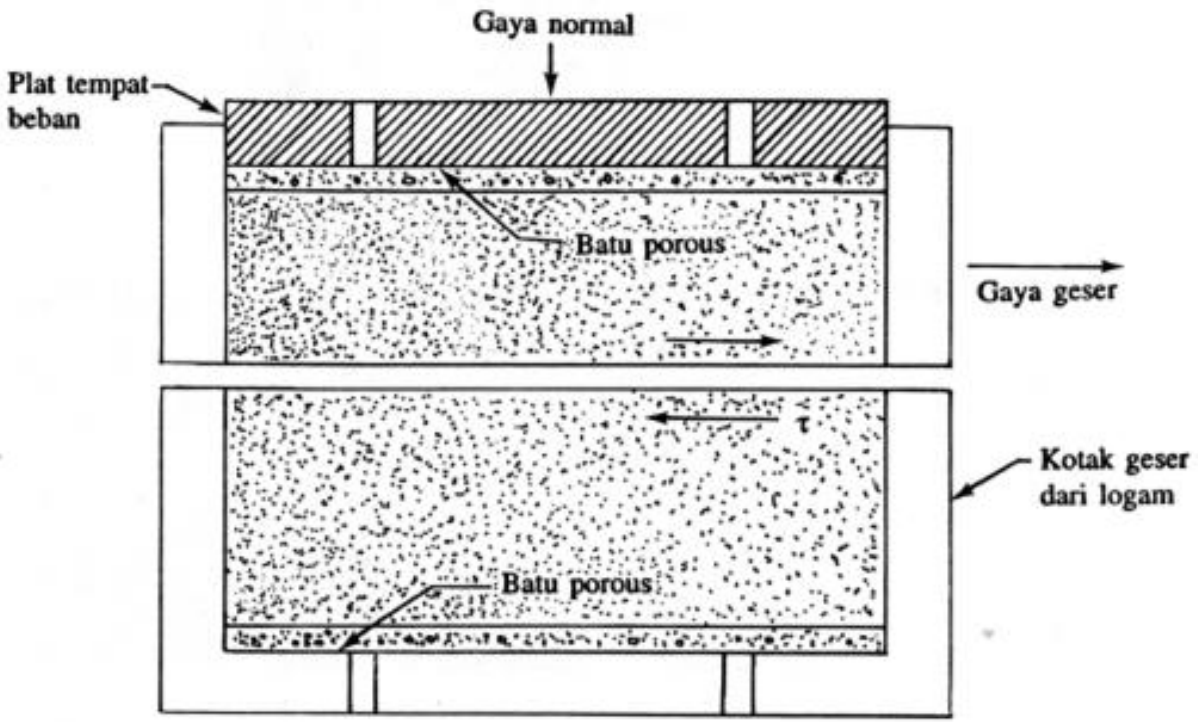

Test Code: 1 = CK$_o$UC
2 = CK$_o$UE
3 = CK$_o$DSS
1
2
45 + ϕ/2
45 − ϕ/2
R
Excavation
Q
Q

Unconfined Compression Test



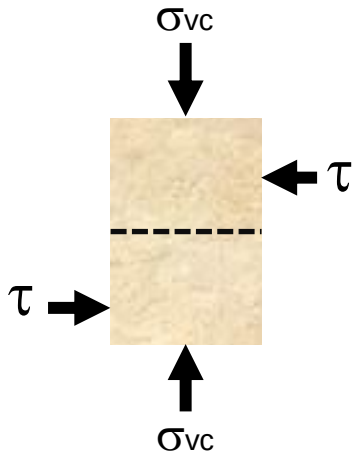


Uji Geser Langsung (Direct Shear Test)



Gambar 9-4 Diagram susunan alat uji geser langsung.

Ni : Beban Vertikal (normal)
Ti. : Gaya horisontal yang diperlukan untuk menggeser ring (tanah)
A : luas penampang tanah
Si : lintasan yang diperlukan sampai tanah tergeser



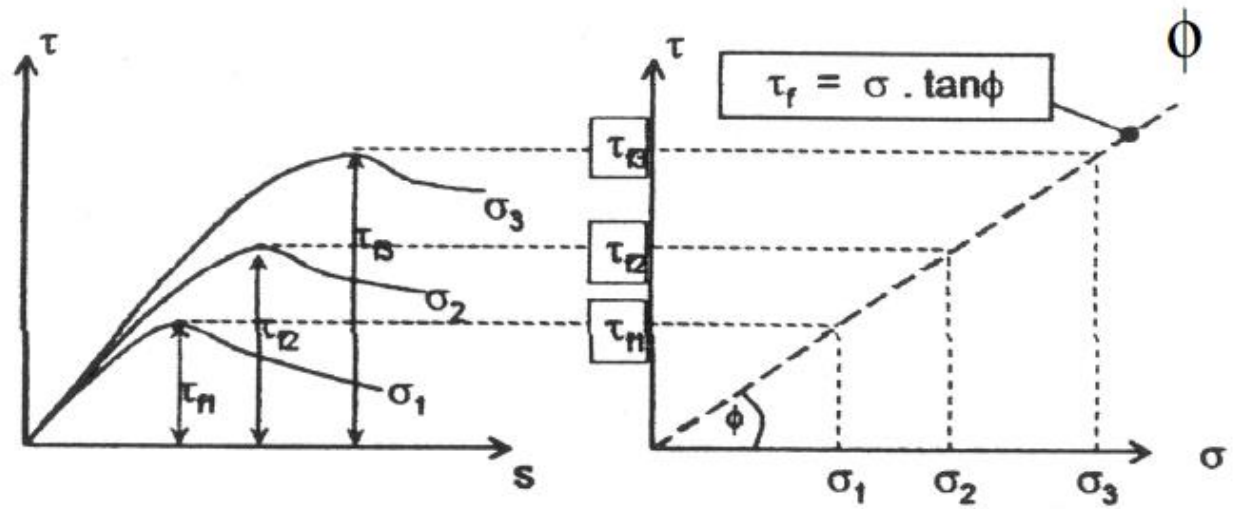
Direct Shear Test pada Tanah Pasir

Uji 1 : $\sigma_1 = \frac{N_1}{A} : \tau_1 = \frac{T_1}{A} : S_1$

Uji 1 : $\sigma_2 = \frac{N_2}{A} : \tau_2 = \frac{T_2}{A} : S_2$

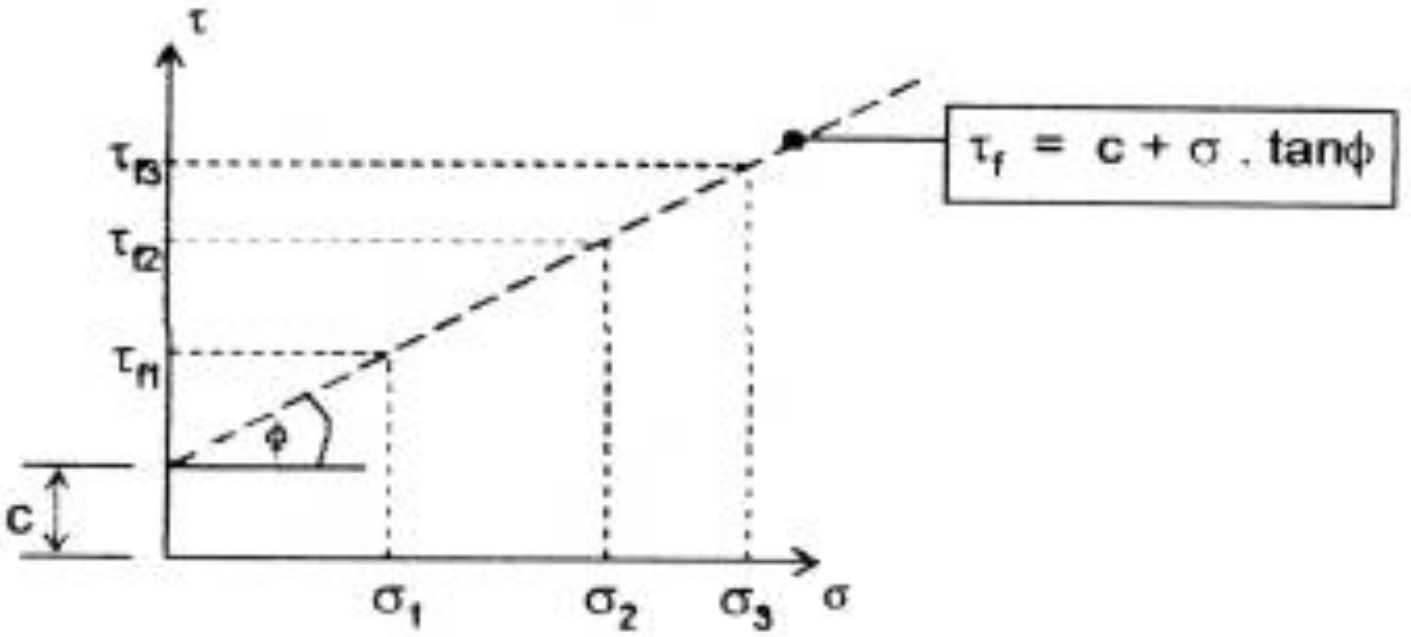
Uji 1 : $\sigma_3 = \frac{N_3}{A} : \tau_3 = \frac{T_3}{A} : S_3$

Hasil Uji



ϕ = sudut geser dalam

Direct Shear Test pada Tanah Lempung



ϕ : sudut geser dalam

c : kohesi [kN/m^2]

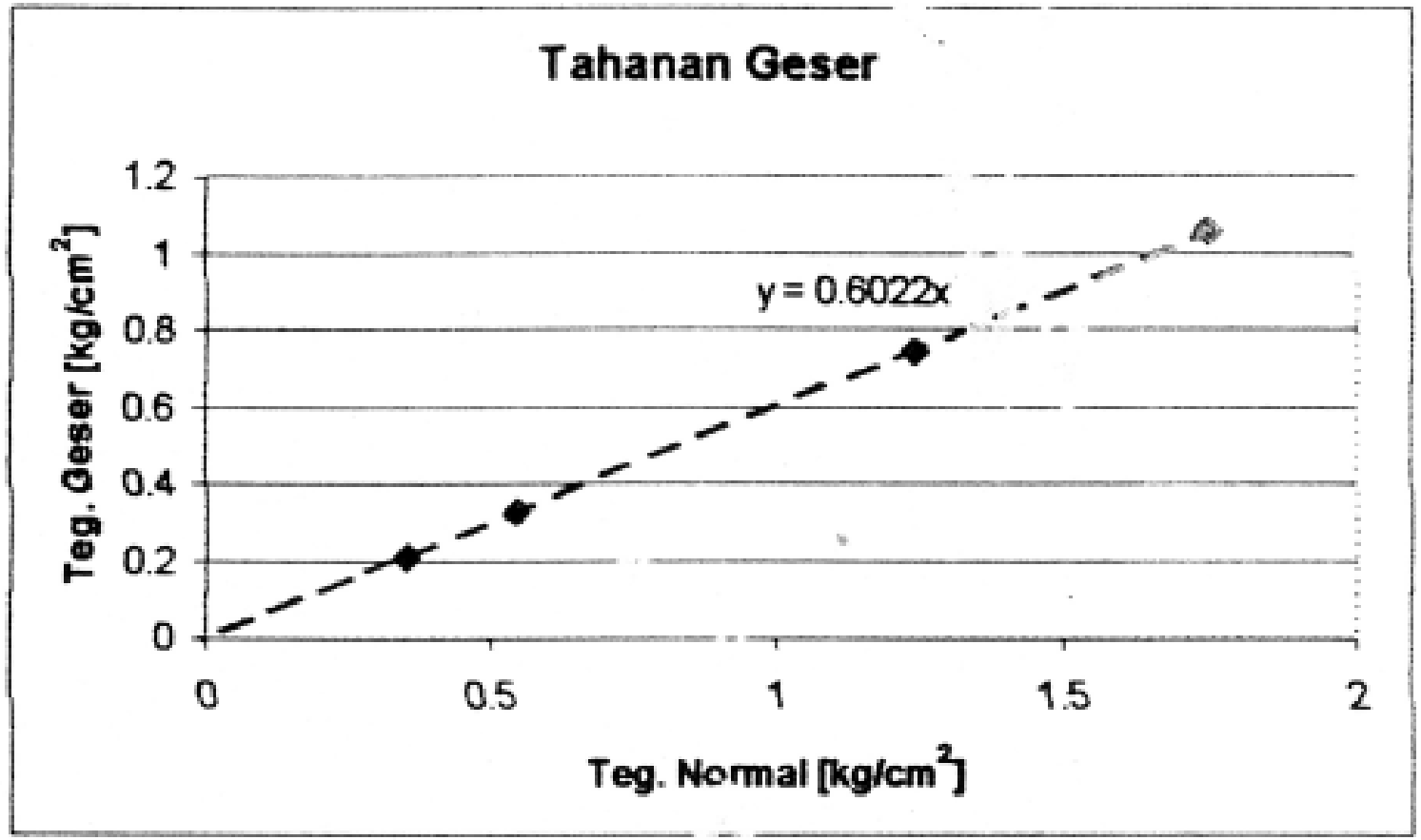
Uji Geser Langsung (Direct Shear Test)

Contoh Tanah Pasir

Luas Sample: A = (5.08*5.08) cm^2

No. Uji	Arah Normal		Arah Geser	
	Gaya	Tegangan	Gaya	Tegangan
	kg	kg/cm^2	kg	kg/cm^2
1	9	0.348751	5.44	0.210924
2	14	0.542501	8.30	0.32166
3	32	1.240002	19.10	0.739993
4	45	1.743753	27.26	1.056638

Uji Geser Langsung (Direct Shear Test)



$\Phi = a \tan(0{,}6022) = 31^{o}$

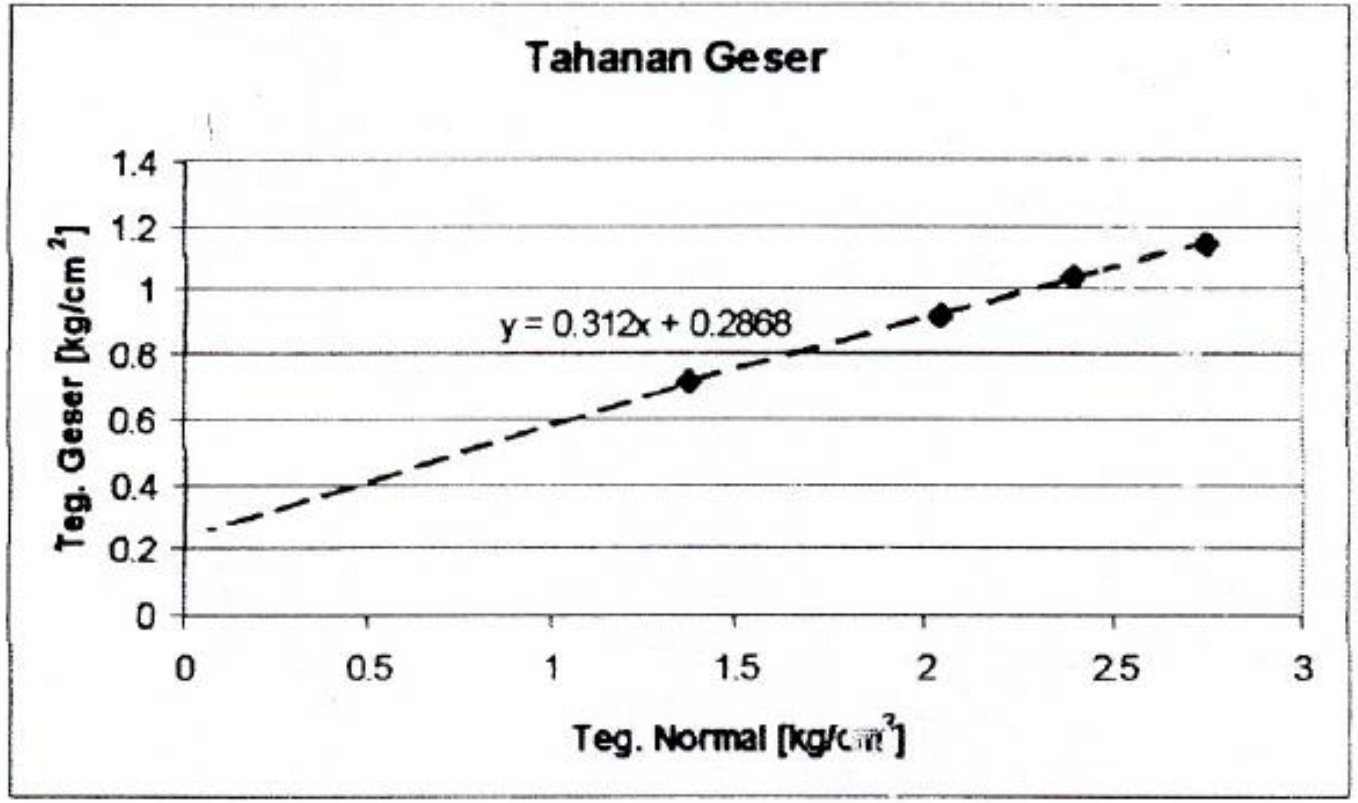
$c = 0$

Uji Geser Langsung (Direct Shear Test)

Contoh Tanah Pasir

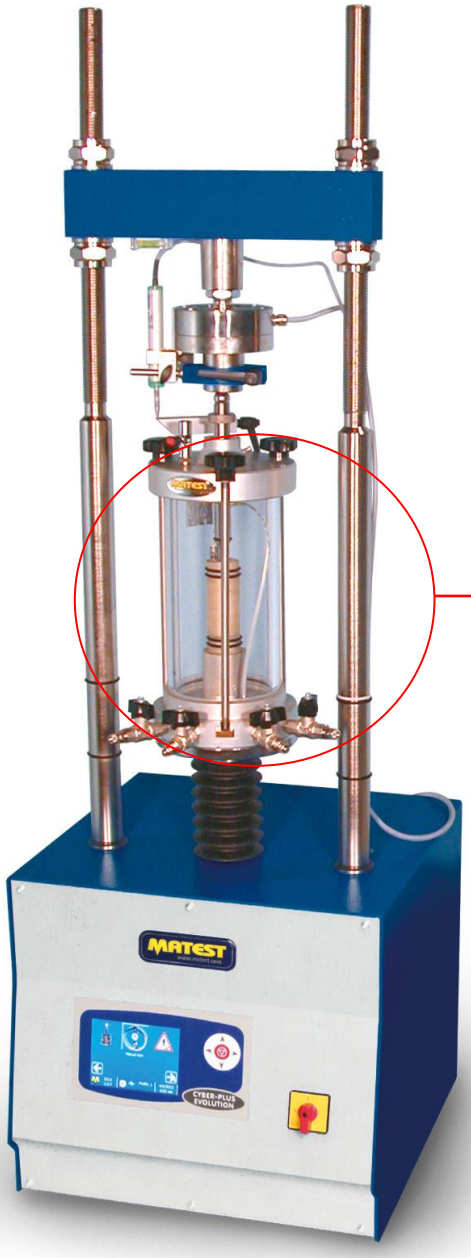
Diameter Sample: D = 5.08 cm

No. Uji	Arah Normal		Arah Geser	
	Gaya	Tegangan	Gaya	Tegangan
	kg	kg/cm^2	kg	kg/cm^2
1	27	1.374545	14.06	0.715782
2	40	2.036363	18.06	0.919418
3	47	2.392727	20.41	1.039054
4	54	2.749091	22.43	1.141891

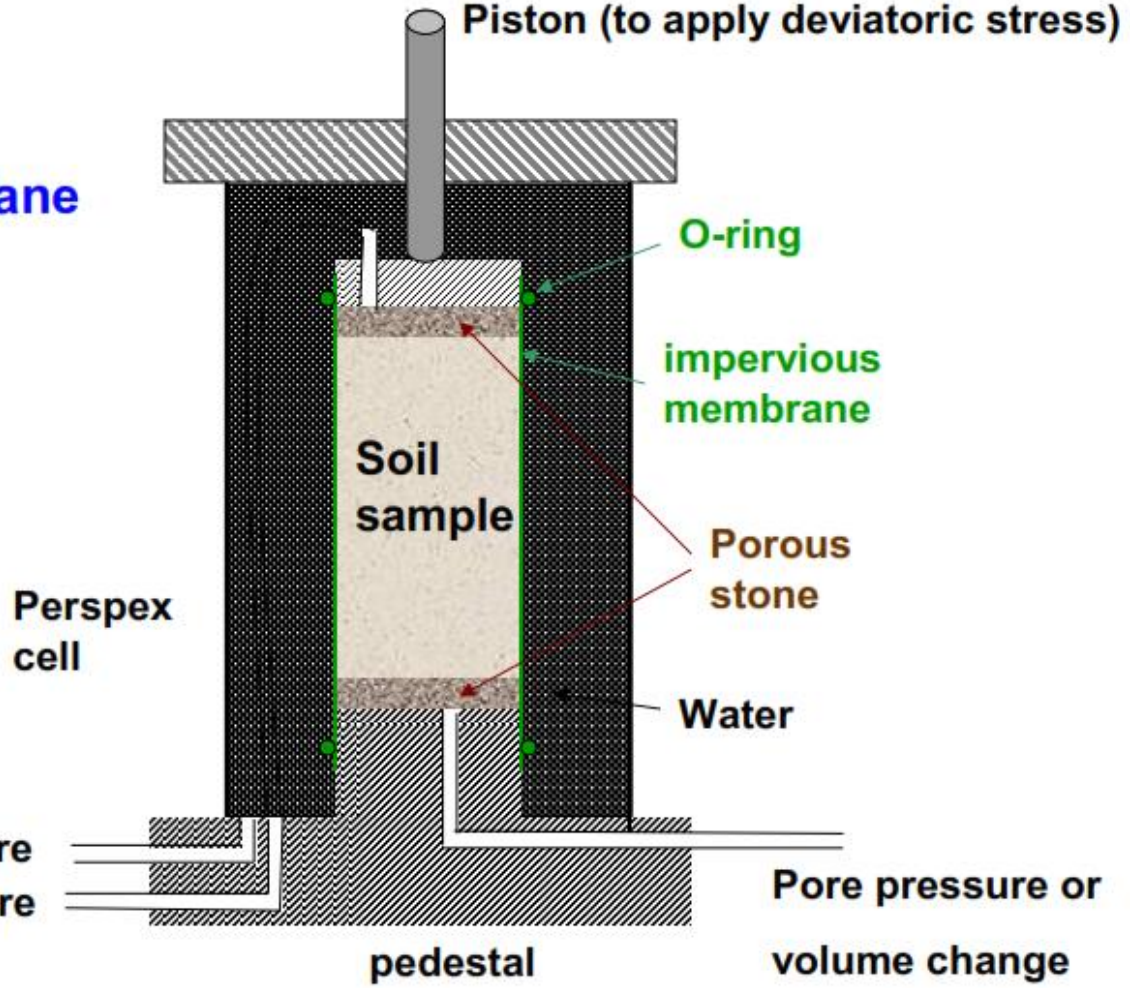


ϕ = atan(0.312) = 17.32^0
c = 0.2868 kg/cm^2

Uji Triaxial (Triaxial Test)



Soil sample at failure



Uji Triaxial (Triaxial Test)

Tiga tipe standard dari uji triaxial yang biasanya dilakukan

1. Consolidated-drained test atau drained test (CD test)
2. Consolidated-undrained test (CU test)
3. Unconsolidated-undrained test atau undrained test (UU test)

Uji Triaxial (Triaxial Test)

Specimen Preparation (Undisturbed Sample)

Sampling tubes

Sample extruder

Uji Triaxial (Triaxial Test)

Specimen Preparation (Undisturbed Sample)

Edges of the sample are carefully trimmed

Setting up the sample in the triaxial cell

Uji Triaxial (Triaxial Test)

Specimen Preparation (Undisturbed Sample)

Sample is covered with a rubber membrane and sealed

Cell is completely filled with water

Uji Triaxial (Triaxial Test)

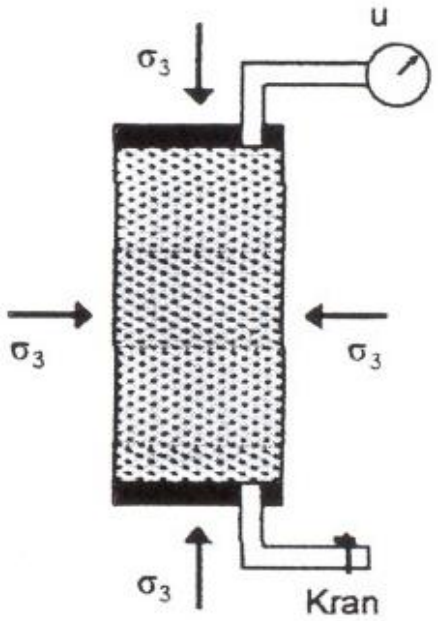
Specimen Preparation (Undisturbed Sample)

Proving ring to measure the deviator load

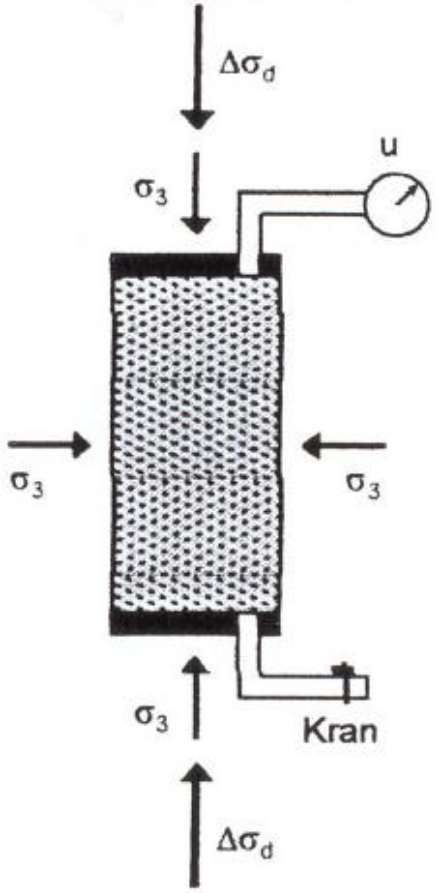
Dial gauge to measure vertical displacement

Prinsip Uji Triaxial

Tahap 1:
Confining Pressure



Tahap 2:
Shear Pressure



Pemberian Beban:

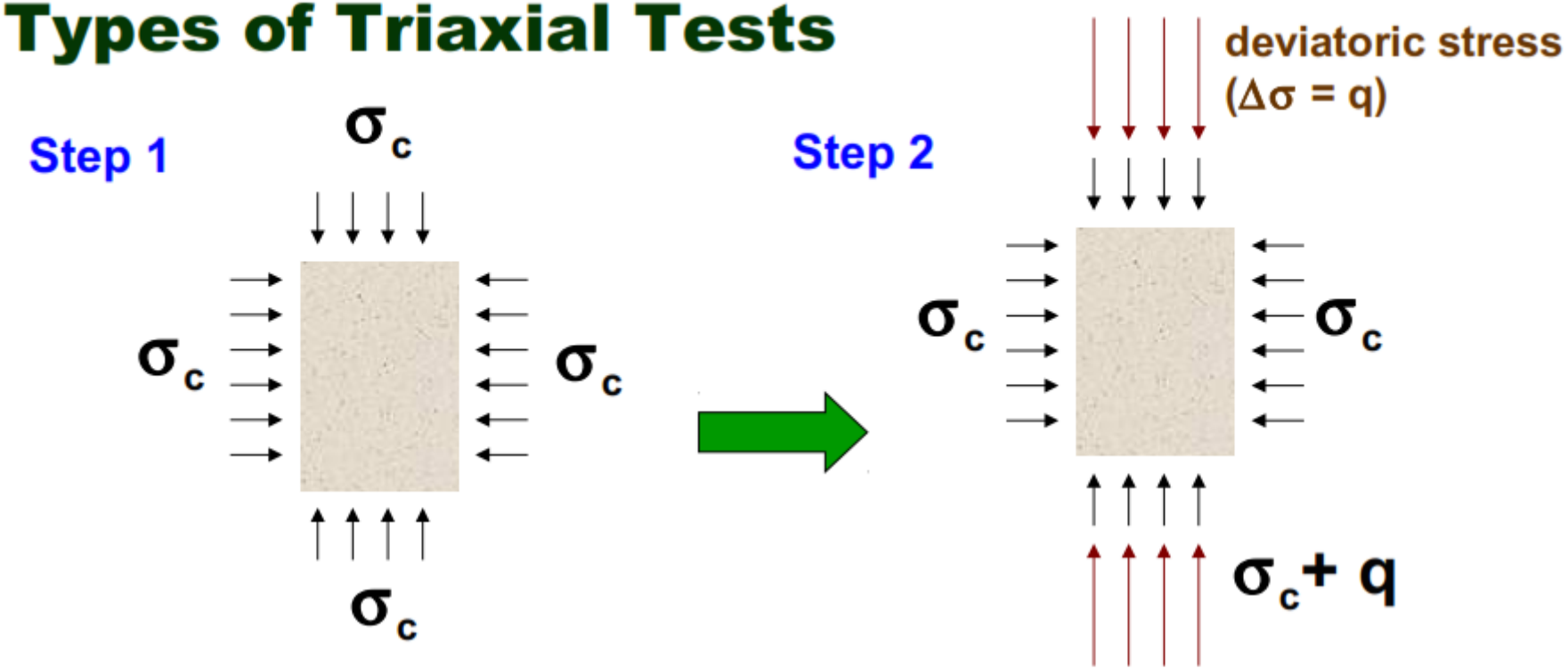
σ_3 : konstan

$\Delta\sigma_d$: bertahap sampai runtuh $(\Delta\sigma_d)_f$

Perbedaan Tipe Standard Pengujian Triaxial

Jenis Uji	Confining Pressure		Shear Pressure	
	Kran	Teg. Air Pori (u)	Kran	Teg. Air Pori (u)
CD	Buka	$u = u_c = 0$	Buka	$u = u_c + \Delta u_d = 0$
CU	Buka	$u = u_c = 0$	Tutup	$u = u_c + \Delta u_d = 0$
UU	Tutup	$u = u_c$	Tutup	$u = u_c + \Delta u_d$

Types of Triaxial Tests



Under all-around cell pressure σ_c

Shearing (loading)

Is the drainage valve open?

yes

no

Consolidated sample

Unconsolidated sample

Is the drainage valve open?

yes

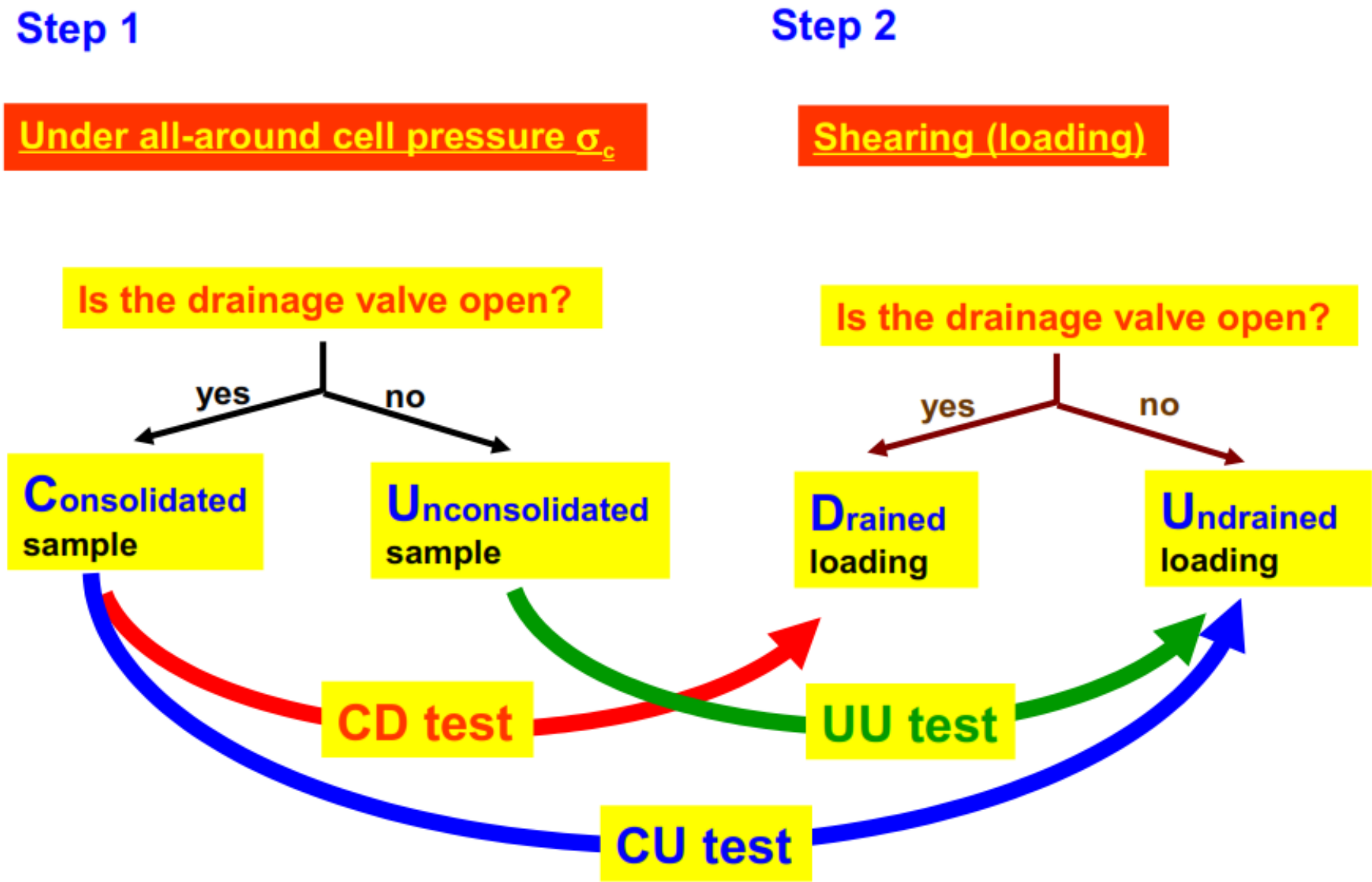
no

Drained loading

Undrained loading

Triaxial Test : Consolidated Drained (CD)

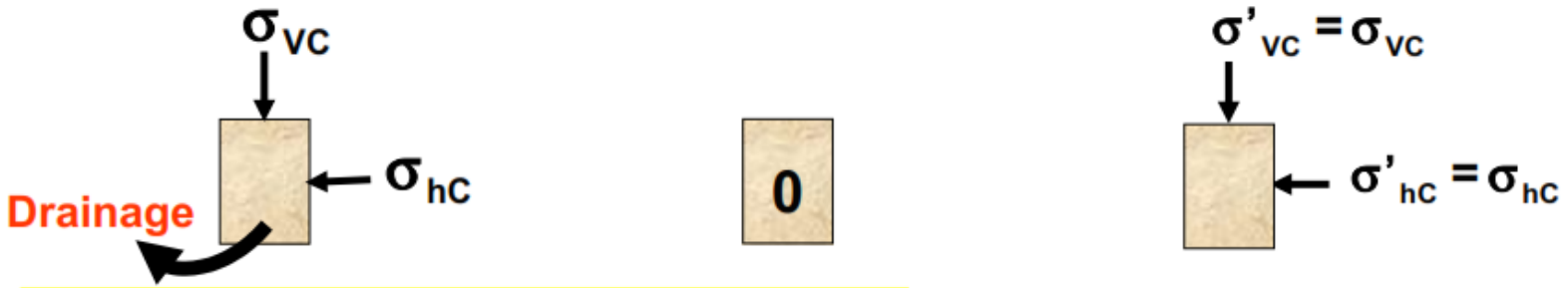
Types of Triaxial Tests



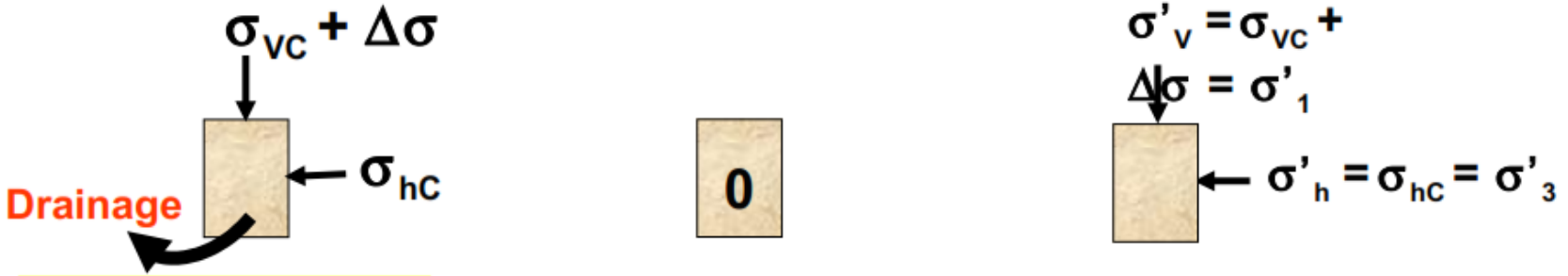
Consolidated- drained test (CD Test)

Total, σ = Neutral, u + Effective, σ'

Step 1: At the end of consolidation

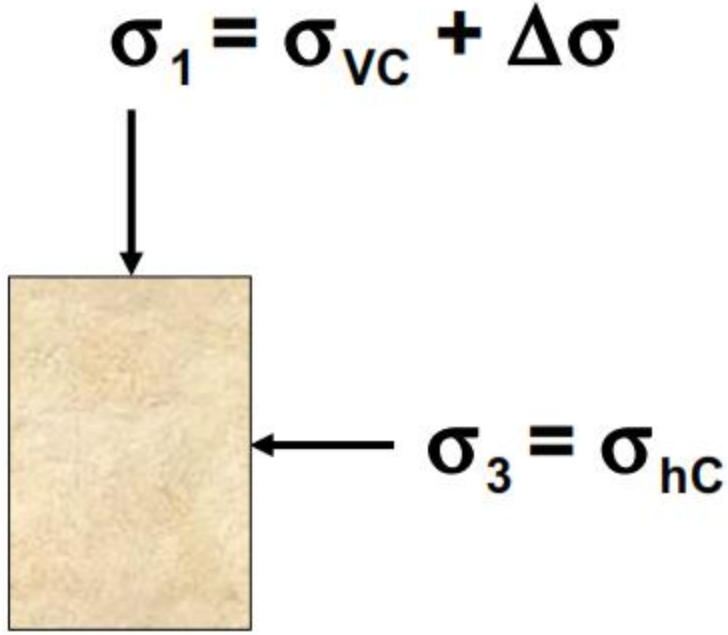


Step 2: During axial stress increase



Step 3: At failure

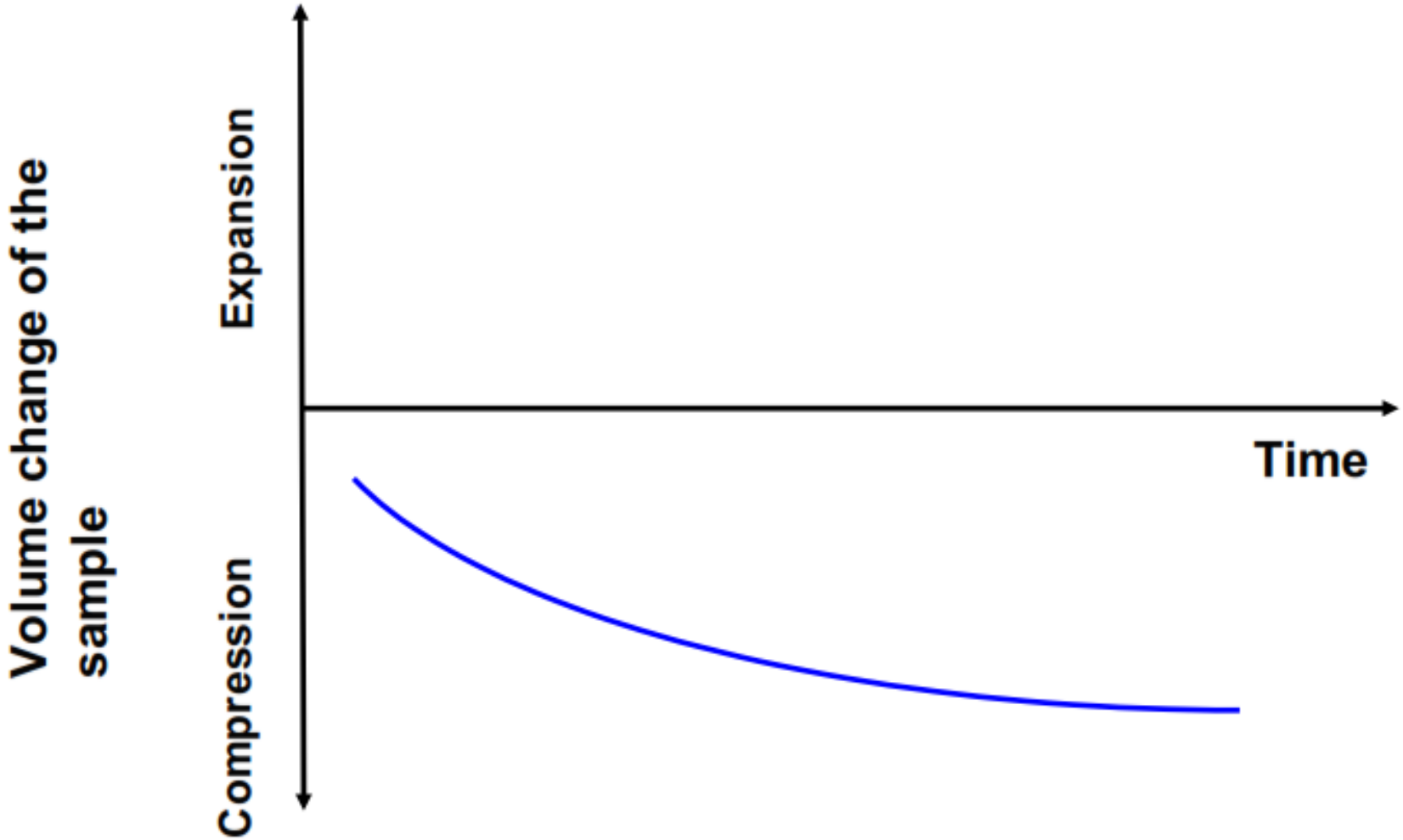
Consolidated- drained test (CD Test)



Deviator stress (q or $\Delta\sigma_d$) = $\sigma_1 - \sigma_3$

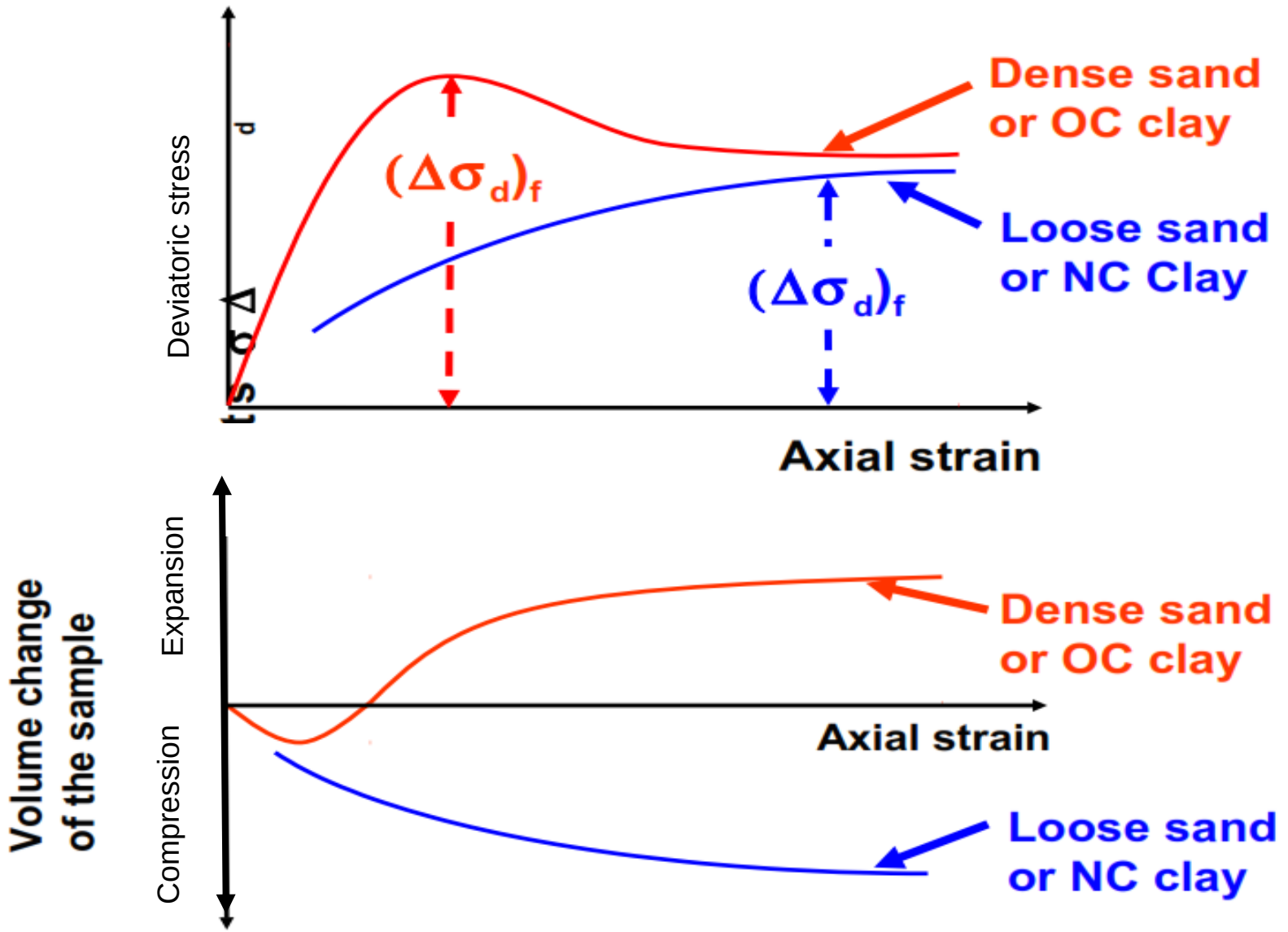
Consolidated- drained test (CD Test)

Volume change of sample during consolidation

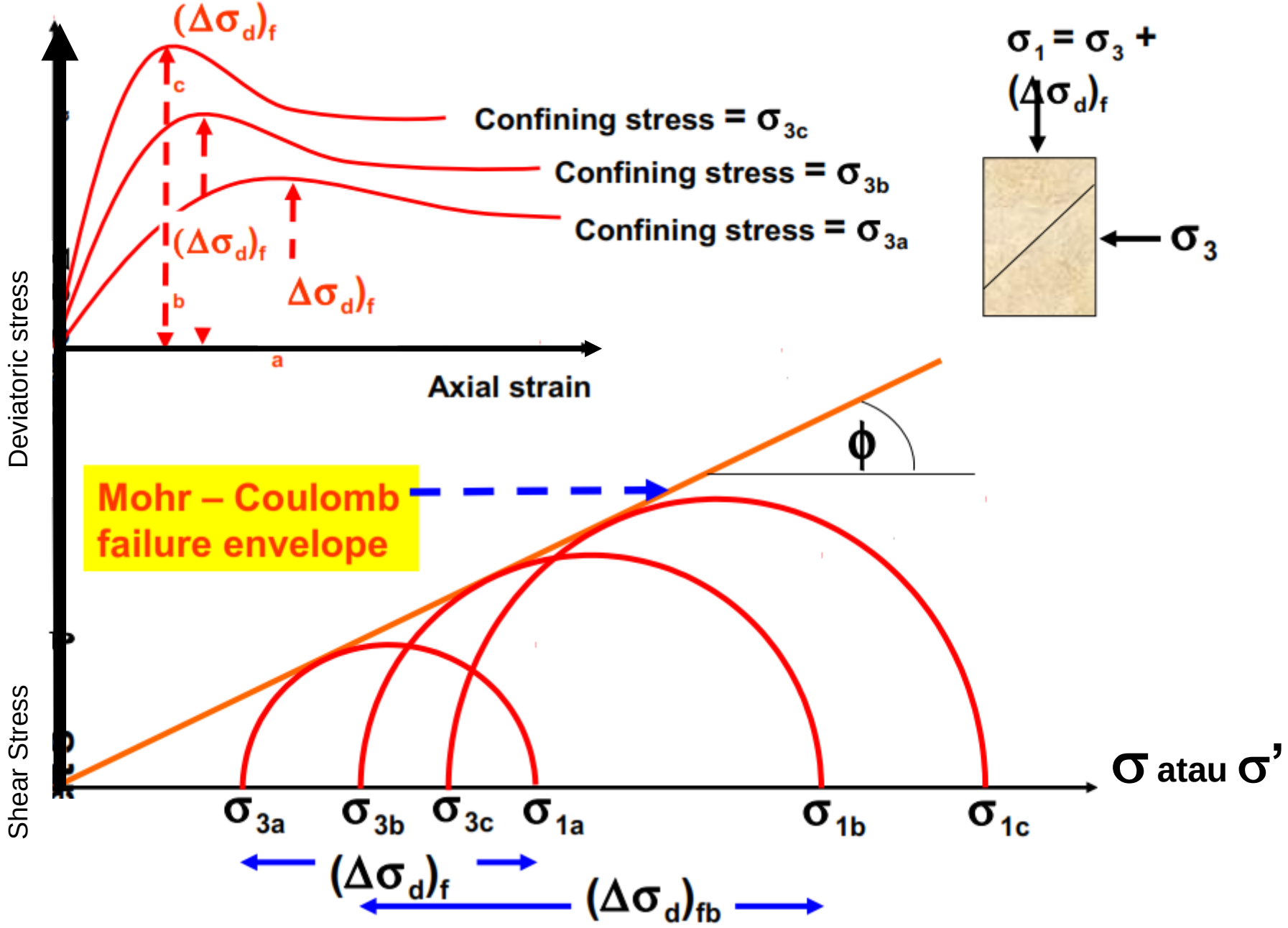


Consolidated- drained test (CD Test)

Stress-strain relationship during shearing

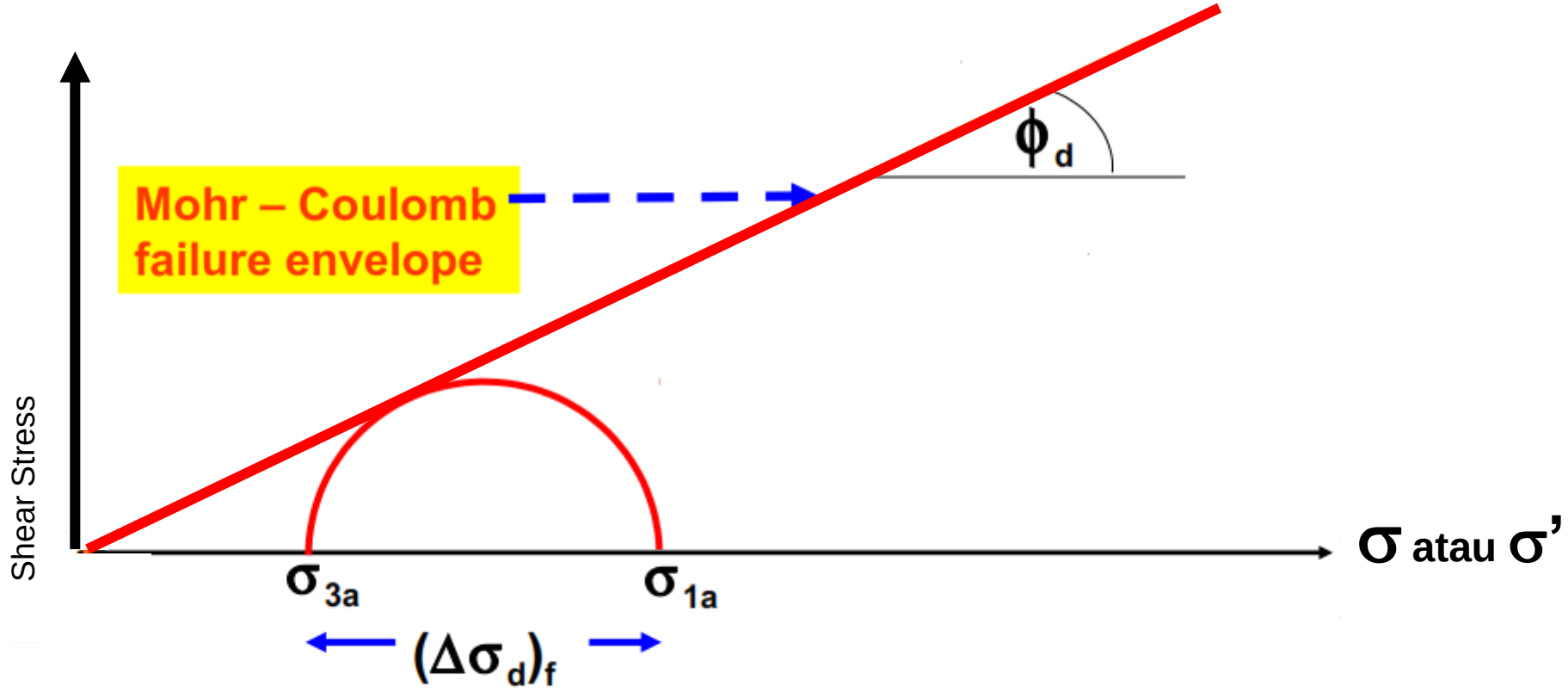


CD tests How to determine strength parameters c and ϕ



CD tests Failure envelopes

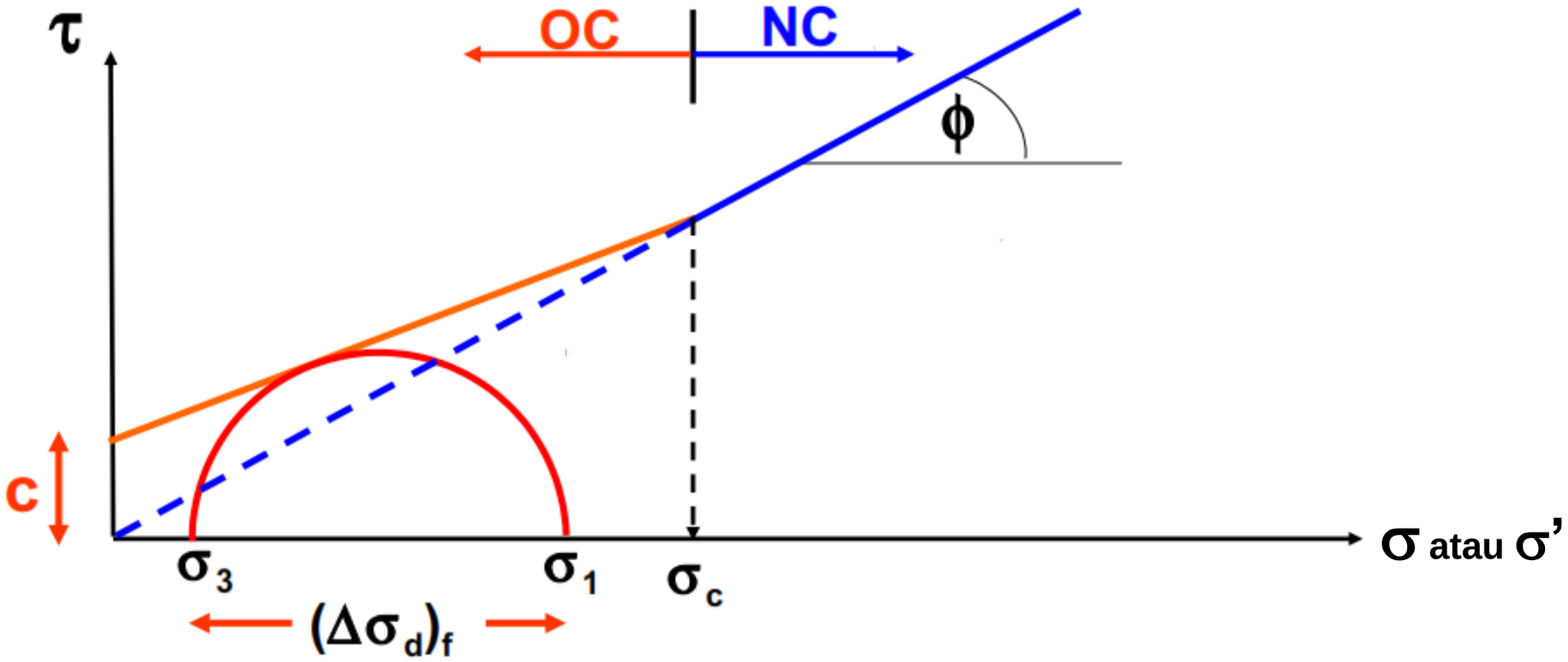
For sand and NC Clay, $c_d = 0$



Therefore, one CD test would be sufficient to determine ϕ_d of sand or NC clay

CD tests Failure envelopes

For OC Clay, $c_d \neq 0$



Triaxial Test : Consolidated Drained (CD)

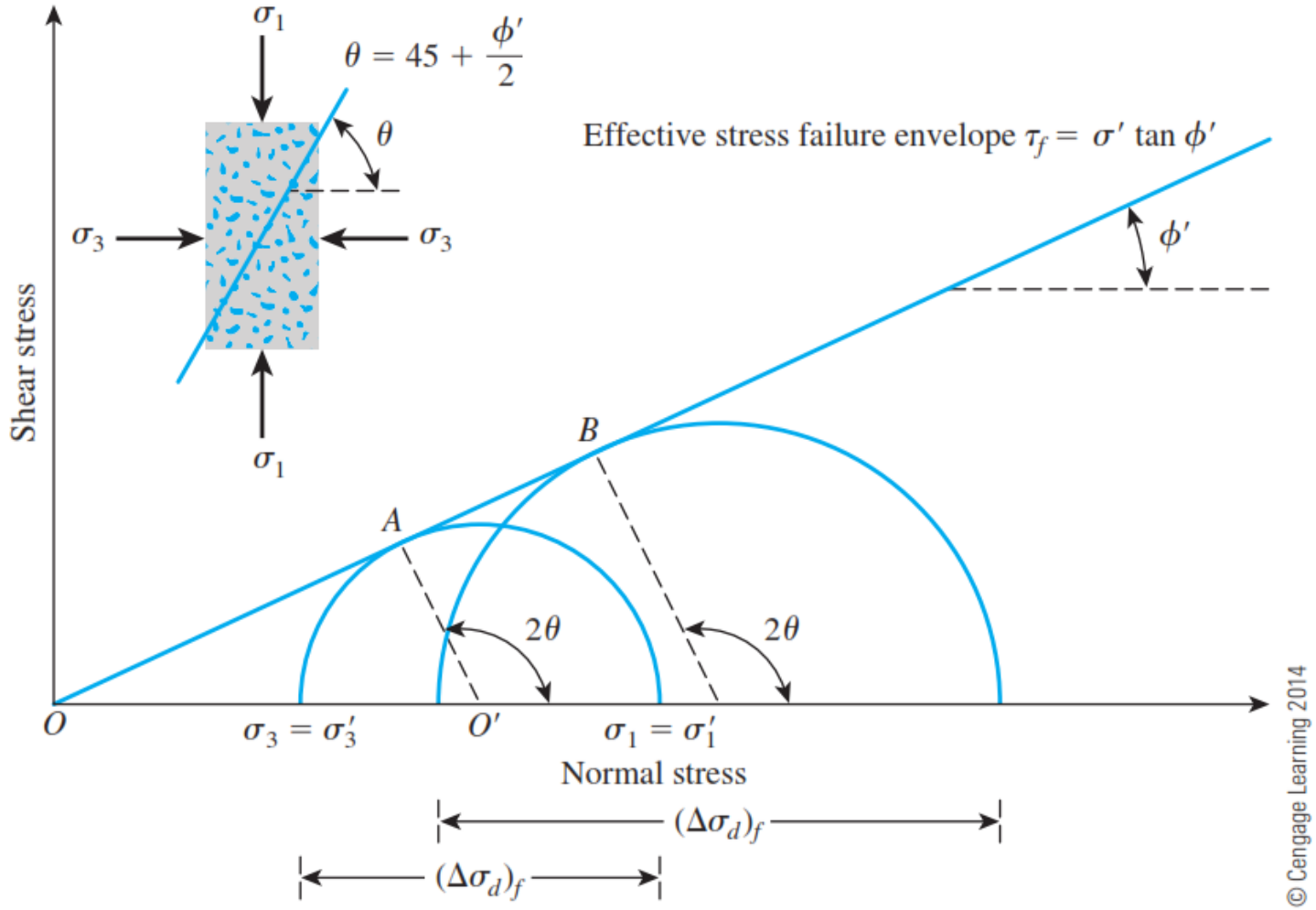


Figure 12.24 Effective stress failure envelope from drained tests on sand and normally consolidated clay

Normally Consolidated (NC)

Triaxial Test : Consolidated Drained (CD)

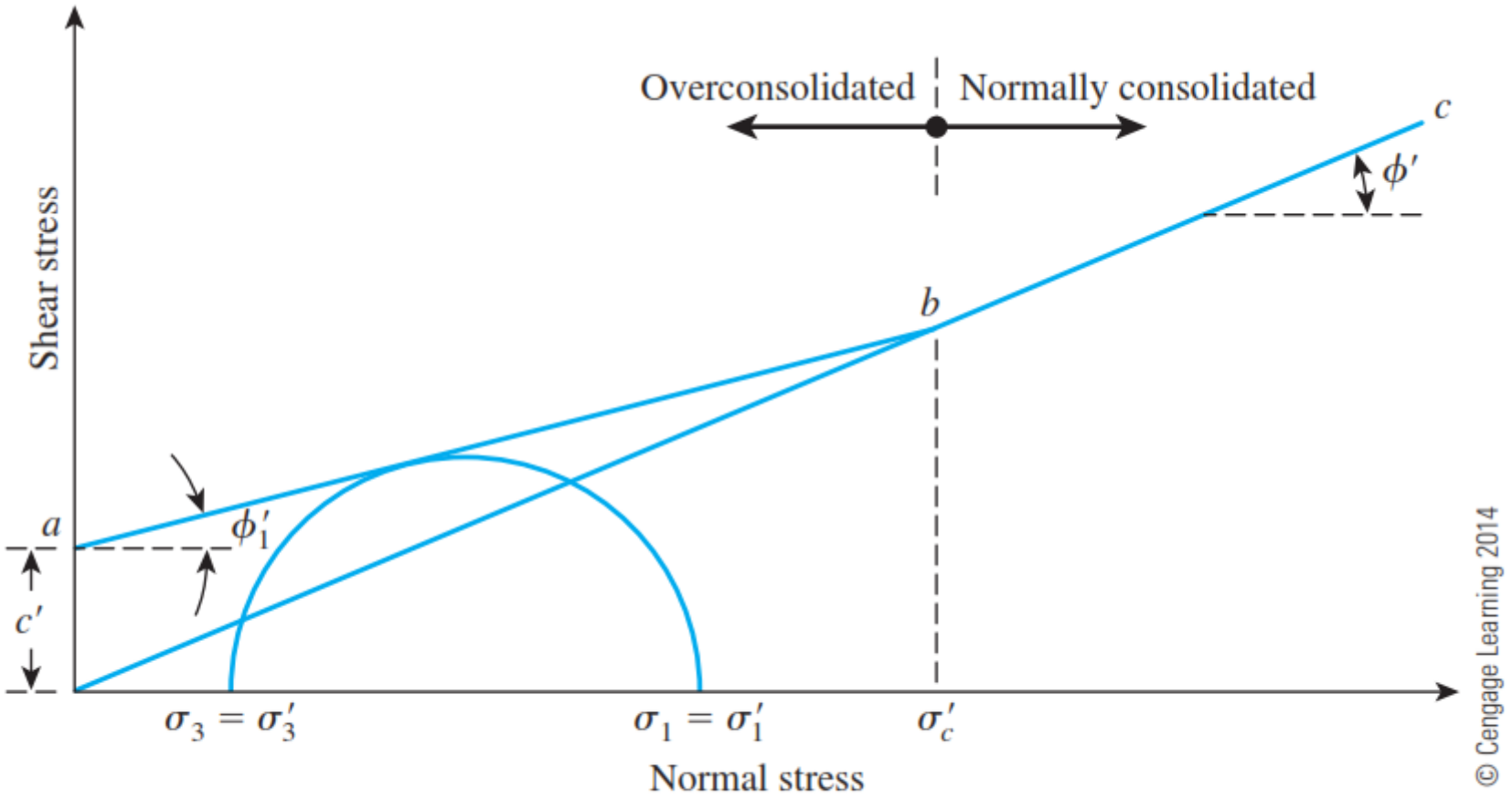


Figure 12.25 Effective stress failure envelope for overconsolidated clay

Overly Consolidated (OC)

Contoh Uji Triaxial 1

Hasil uji triaxial cara air teralirkan terkonsolidasi (CD) pada tanah lempung NC adalah sebagai berikut:

$\sigma 3 \quad = 276 \text{ kN/m}^2$

$(\Delta\sigma d)f \quad = 276 \text{ kN/m}^2$

Tentukan:

a. Sudut Geser, ∅
b. Sudut θ (sudut antara bidang keruntuhan dengan bidang utama besar/major principal plane)

Contoh Uji Triaxial 1

Penyelesaian:

Untuk tanah NC, persamaan garis keruntuhannya adalah:

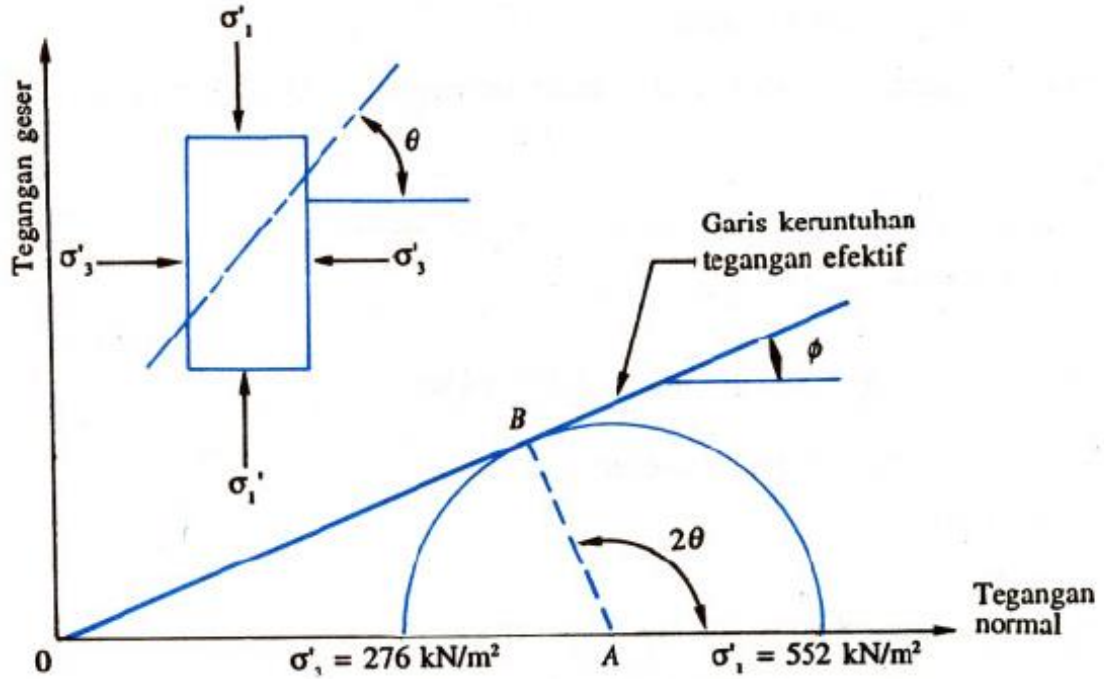
$\tau_1 = \sigma' tan\emptyset$

Pada uji triaxial baik tegangan utama besar maupun kecil pada saat terjadi keruntuhan adalah:

$\sigma_1' = \sigma_1 + \sigma_3 + \left((\Delta\sigma_d\right)_f = 276 + 276 = 552\ \text{kN/m}^2$

Dan

$\sigma_3 = \sigma_3 = 276\ \text{kN/m}^2$



Gambar 9-16

Representative values for angle of internal friction ϕ

Soil	Type of test*		
	Unconsolidated-undrained, U	Consolidated-undrained, CU	Consolidated-drained, CD
Gravel			
Medium size	40–55°		40–55°
Sandy	35–50°		35–50°
Sand			
Loose dry	28–34°		
Loose saturated	28–34°		
Dense dry	35–46°		43–50°
Dense saturated	1–2° less than dense dry		43–50°
Silt or silty sand			
Loose	20–22°		27–30°
Dense	25–30°		30–35°
Clay	0° if saturated	3–20°	20–42°

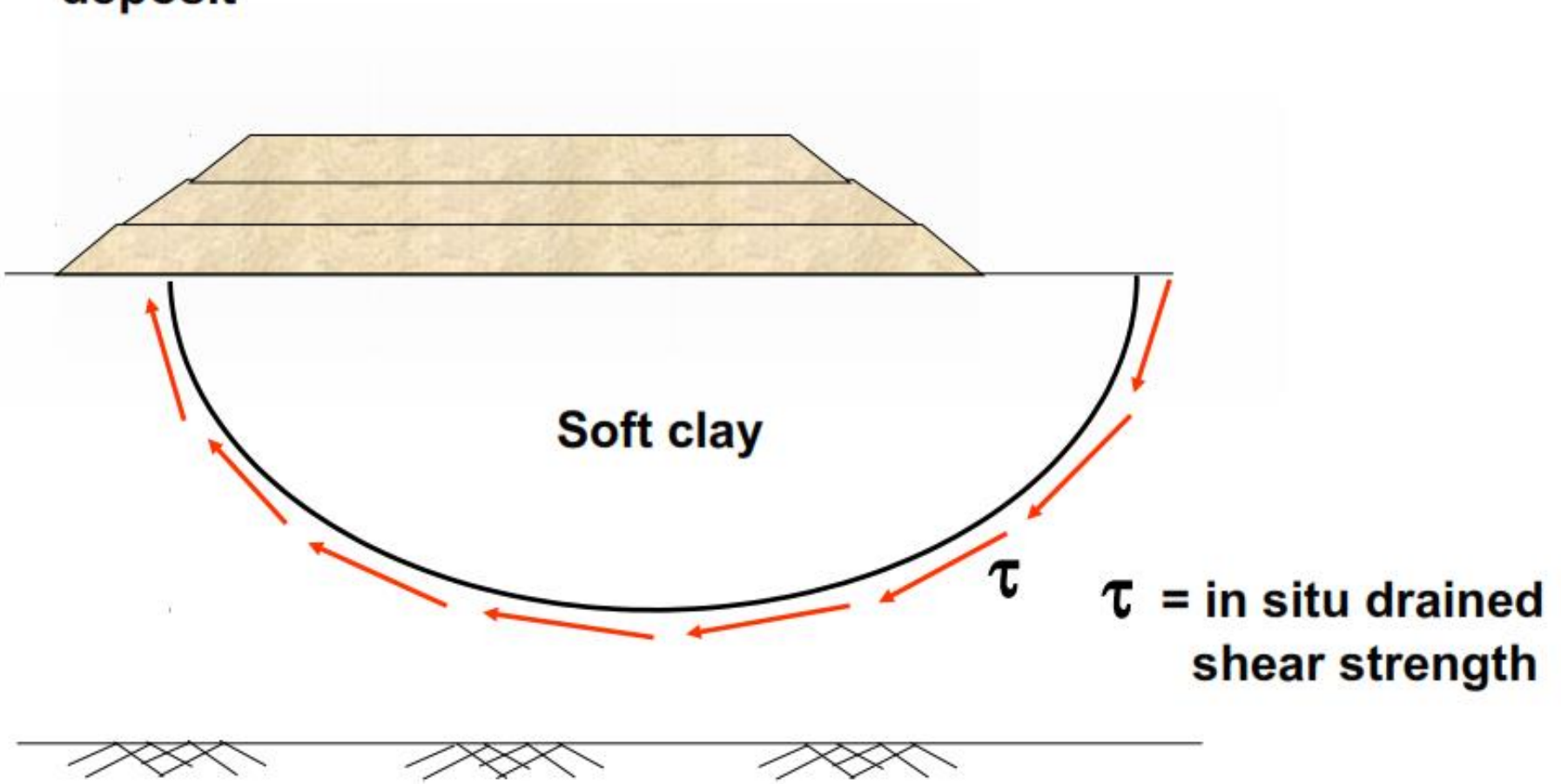
*See a laboratory manual on soil testing for a complete description of these tests, e.g., Bowles (1992).

Notes:

1. Use larger values as γ increases.
2. Use larger values for more angular particles.
3. Use larger values for well-graded sand and gravel mixtures (GW, SW).
4. Average values for gravels, 35–38°; sands, 32–34°.

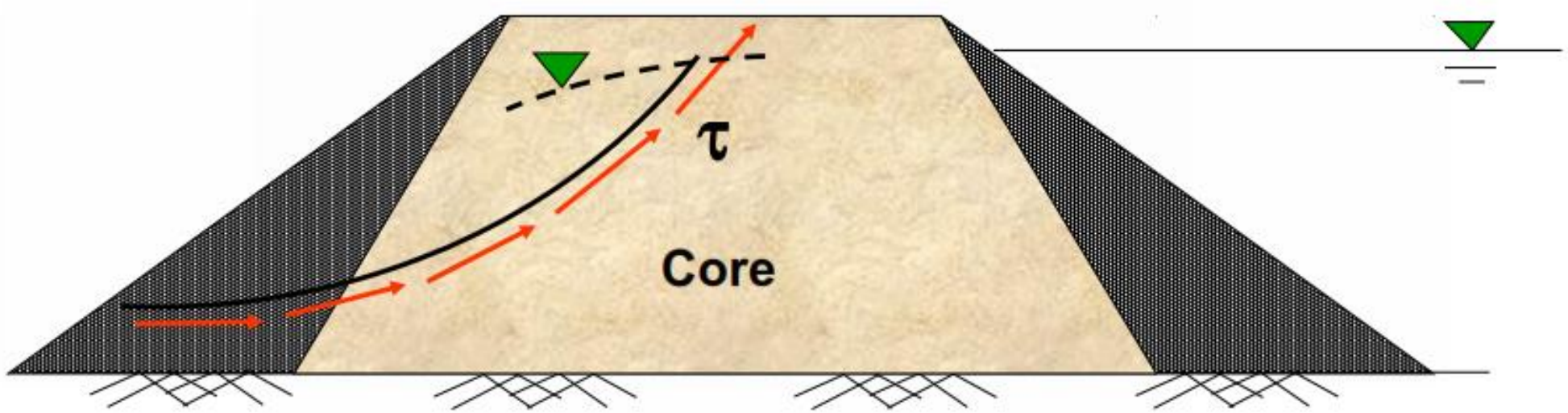
Beberapa contoh penerapan analisis CD pada tanah lempung

1. Embankment constructed very slowly, in layers over a soft clay deposit



Beberapa contoh penerapan analisis CD pada tanah lempung

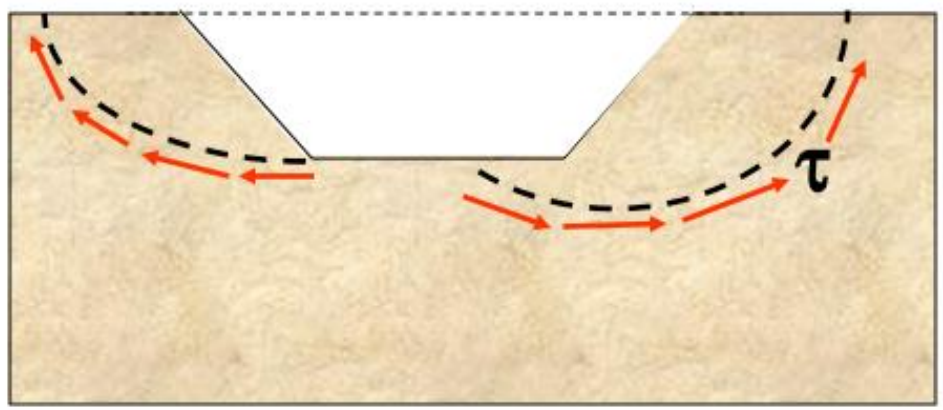
2. Earth dam with steady state seepage

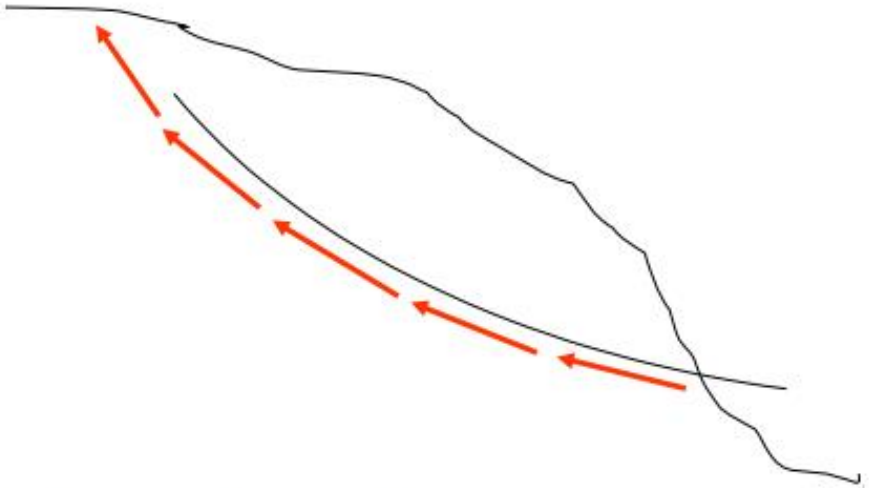


τ = drained shear strength of clay core

Beberapa contoh penerapan analisis CD pada tanah lempung

3. Excavation or natural slope in clay





τ = In situ drained shear strength

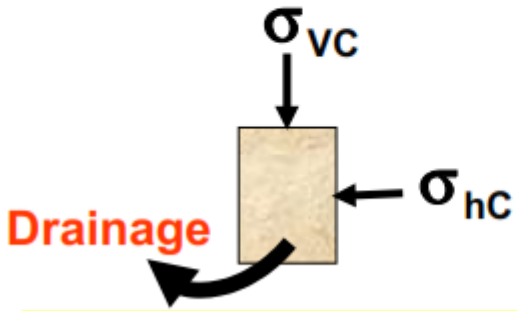
Note: CD test simulates the long term condition in the field. Thus, c_d and ϕ_d should be used to evaluate the long term behavior of soils

Triaxial Test : Consolidated Undrained (CU)

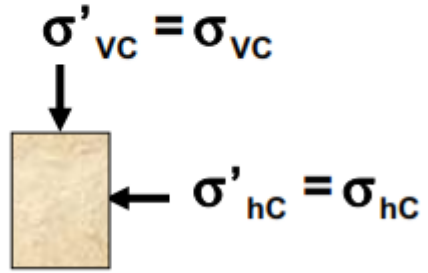
Consolidated- Undrained test (CU Test)

Total, σ = **Neutral, u** + **Effective, σ'**

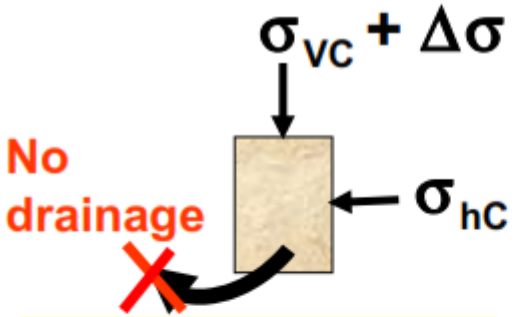
Step 1: At the end of consolidation



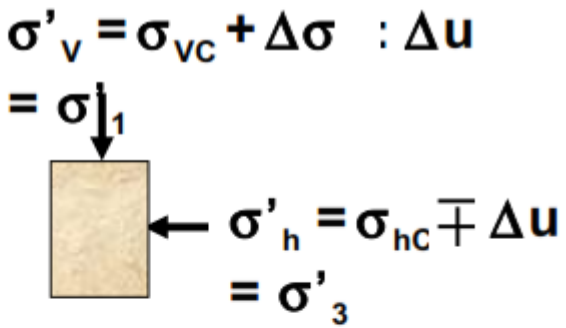
0



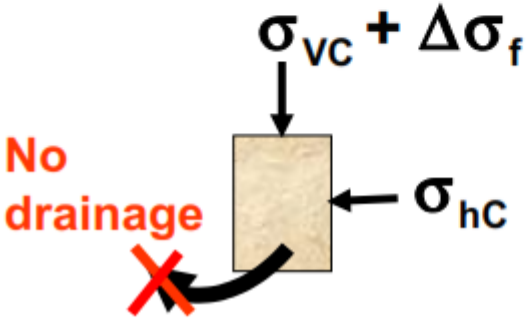
Step 2: During axial stress increase



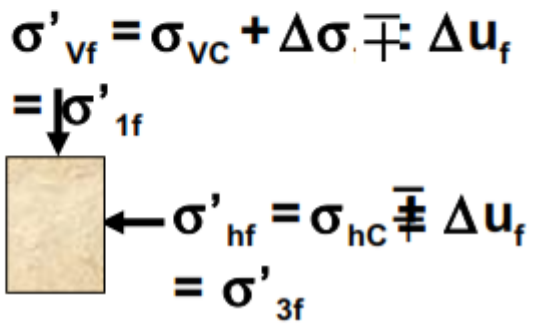
±Δu



Step 3: At failure

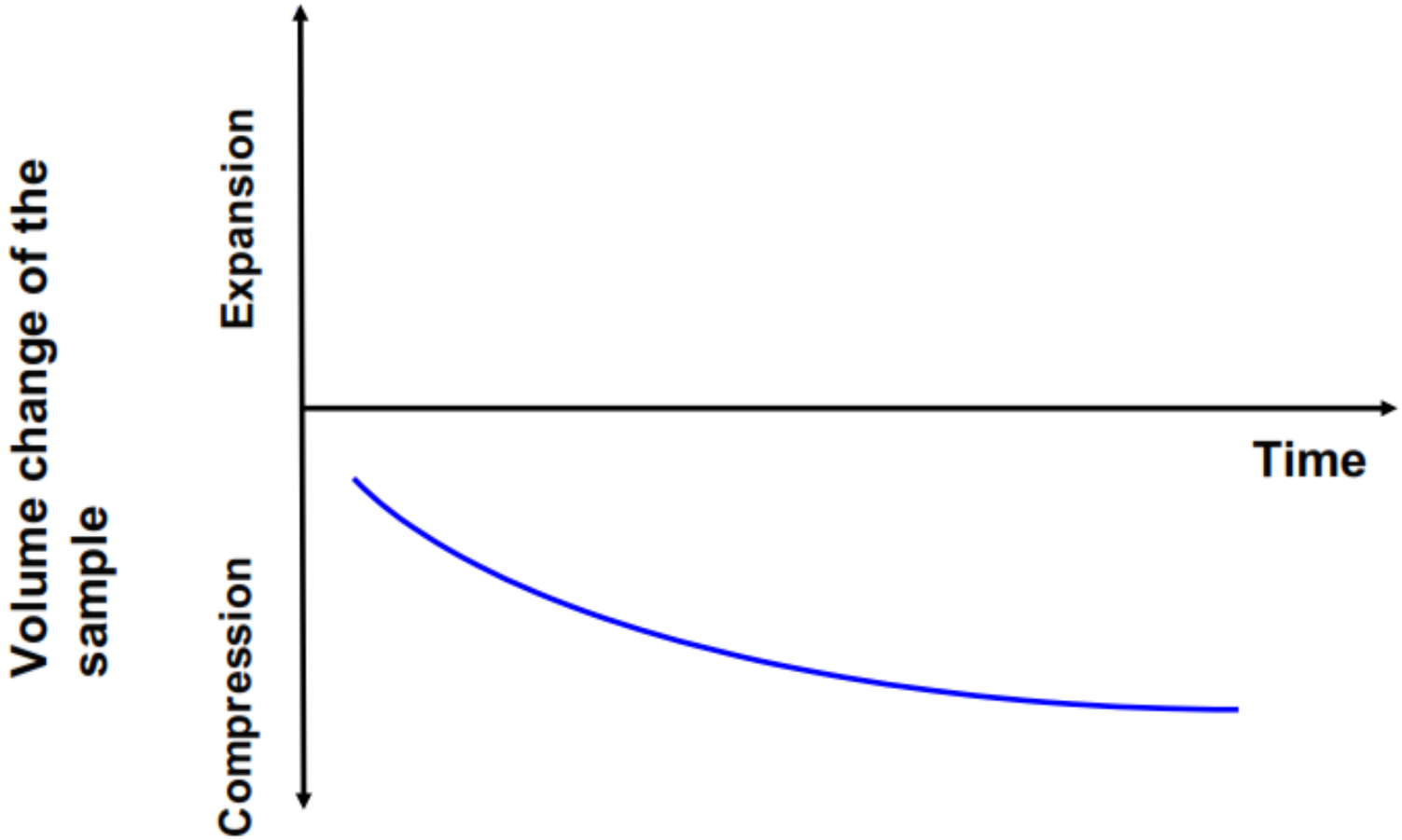


±Δuf



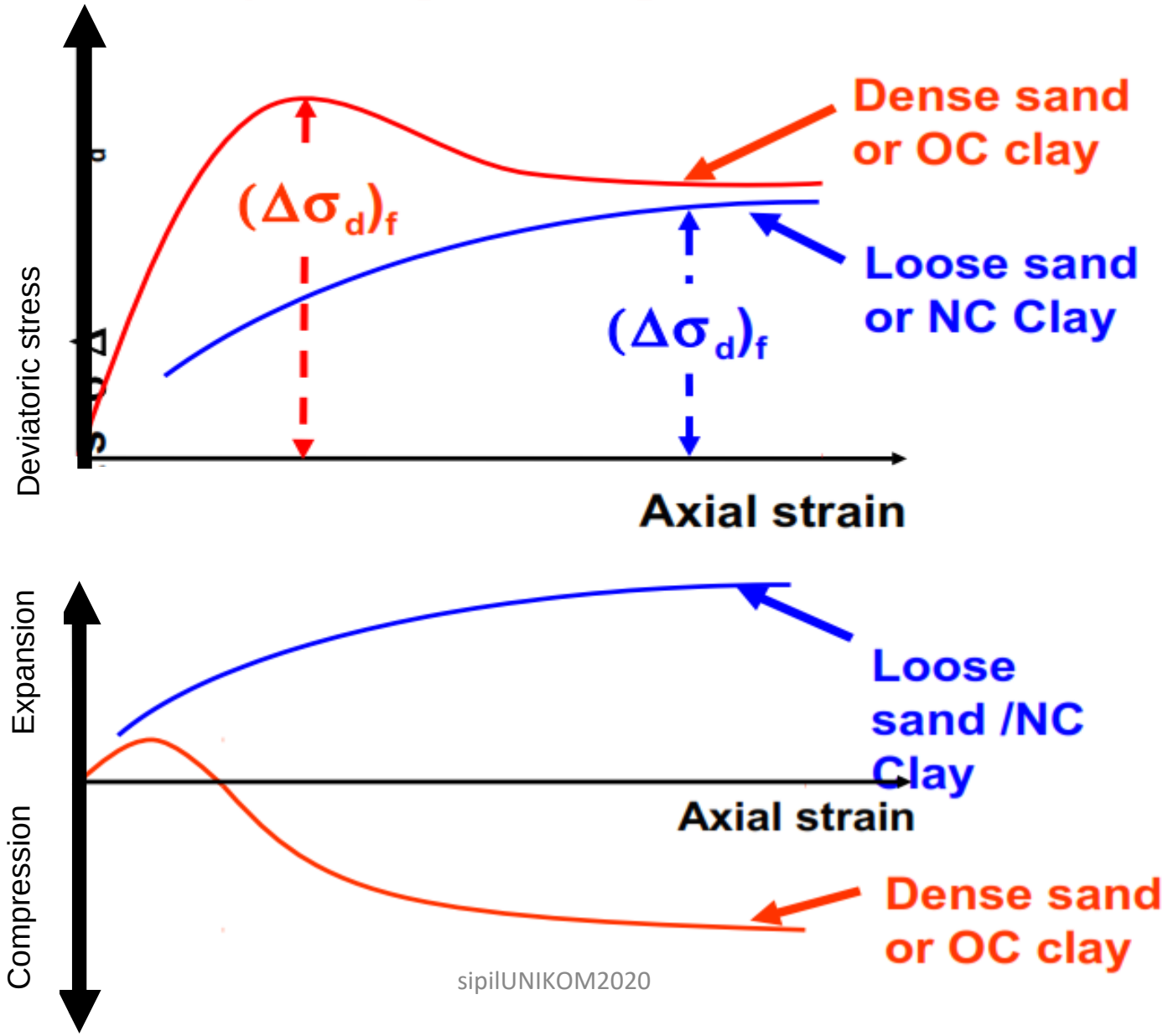
Consolidated- Undrained test (CU Test)

Volume change of sample during consolidation

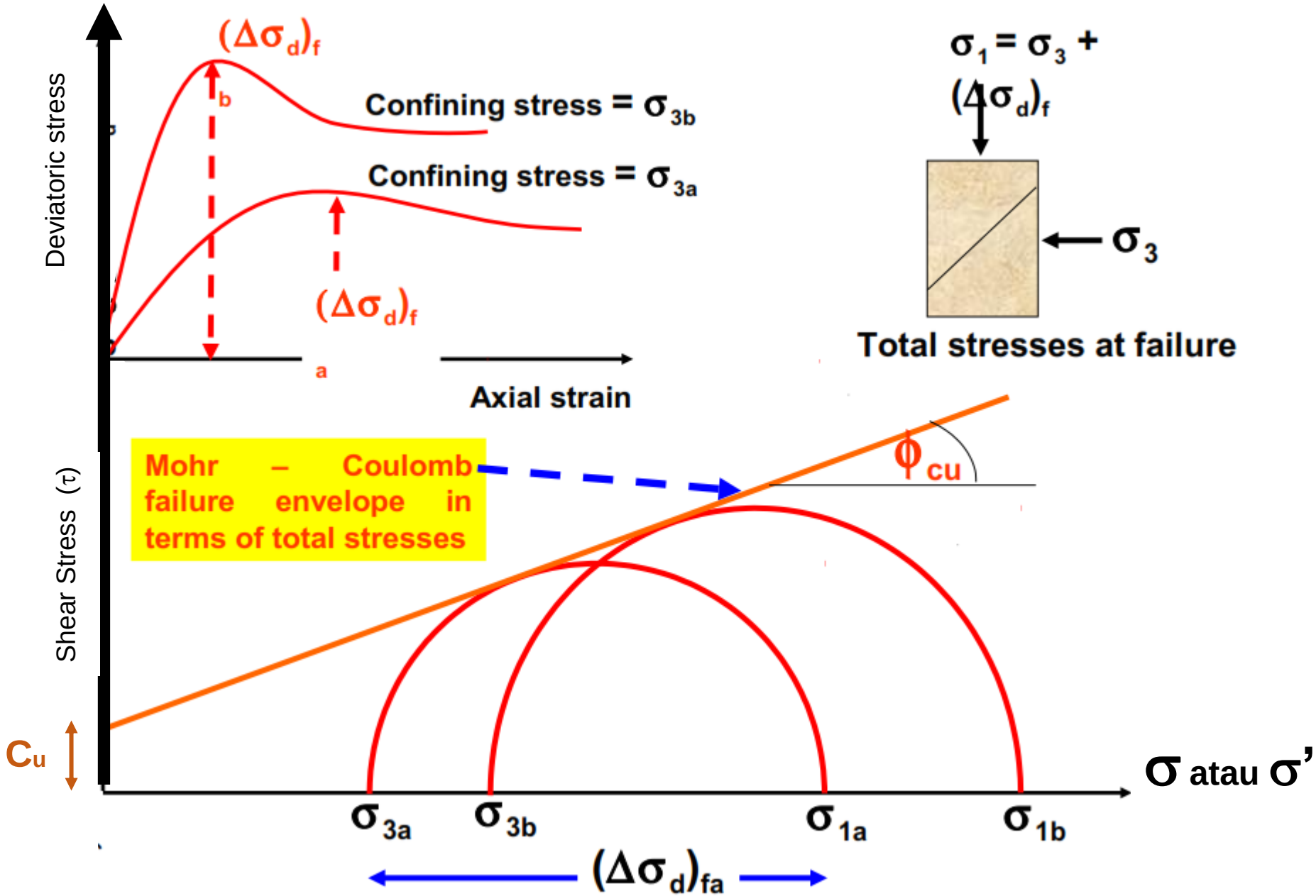


Consolidated- Undrained test (CU Test)

Stress-strain relationship during shearing



CU tests How to determine strength parameters c and ϕ



Triaxial Test : Consolidated Undrained (CU)

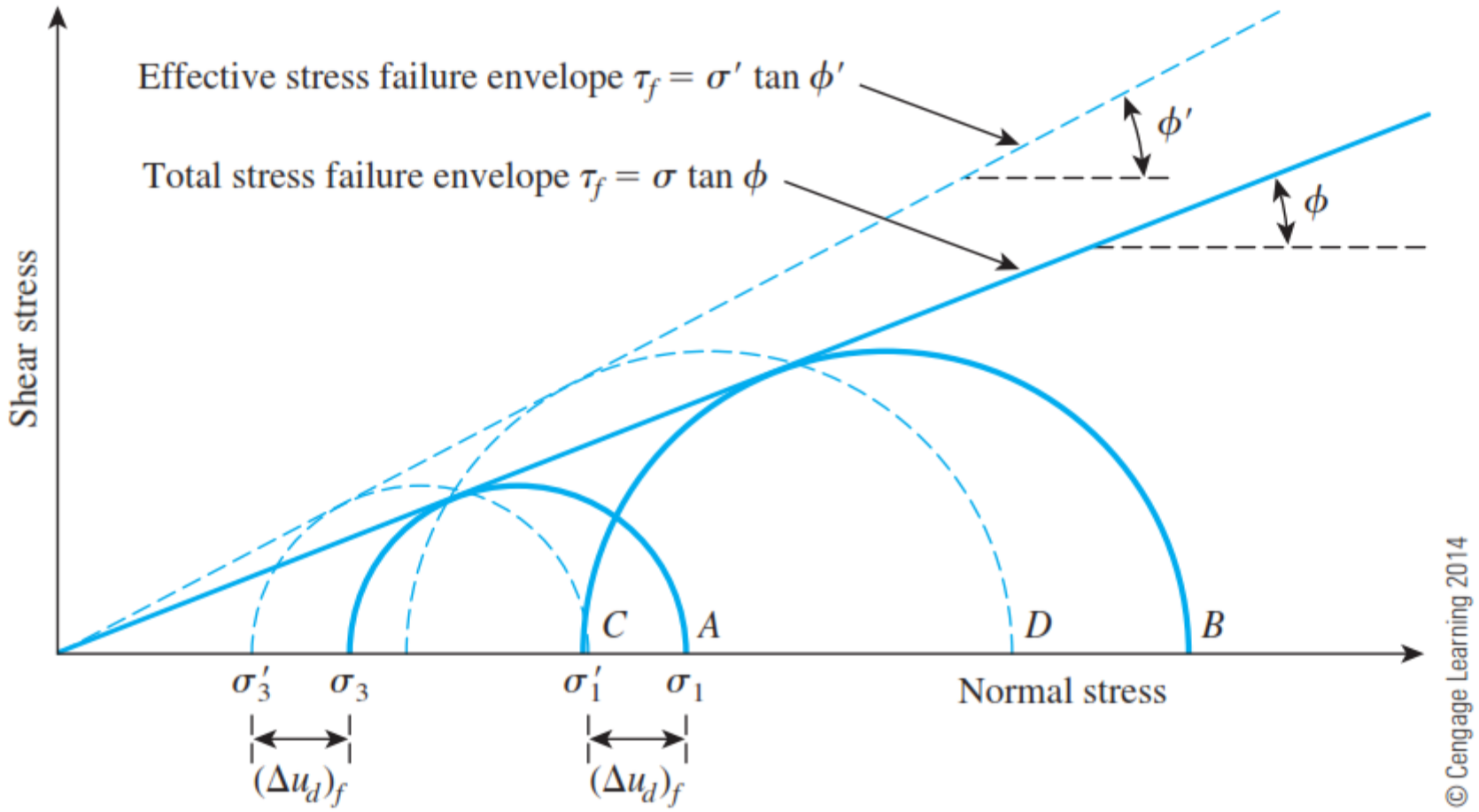


Figure 12.30 Total and effective stress failure envelopes for consolidated undrained triaxial tests.

Normally Consolidated (NC)

Triaxial Test : Consolidated Undrained (CU)

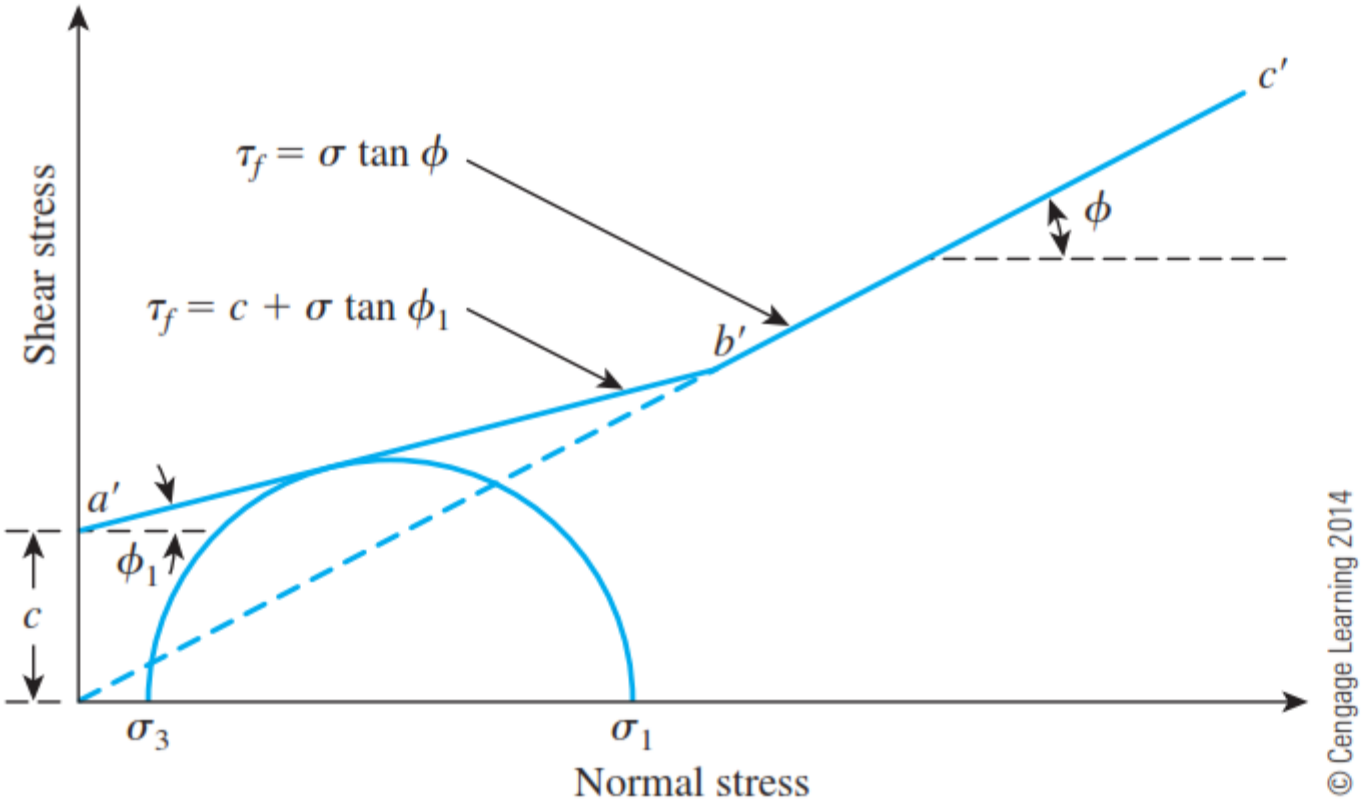
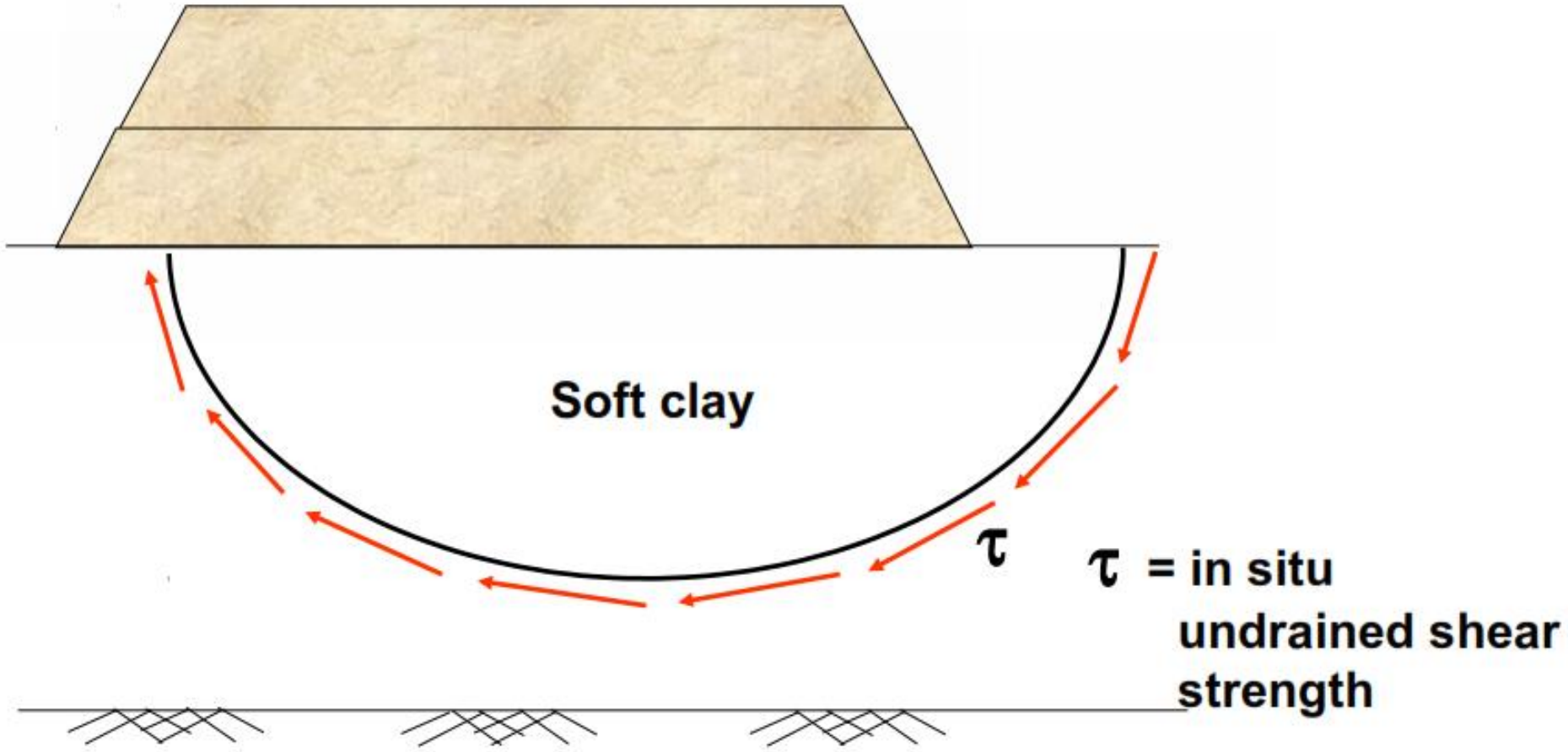


Figure 12.31 Total stress failure envelope obtained from consolidated-undrained tests in overconsolidated clay

Overly Consolidated (OC)

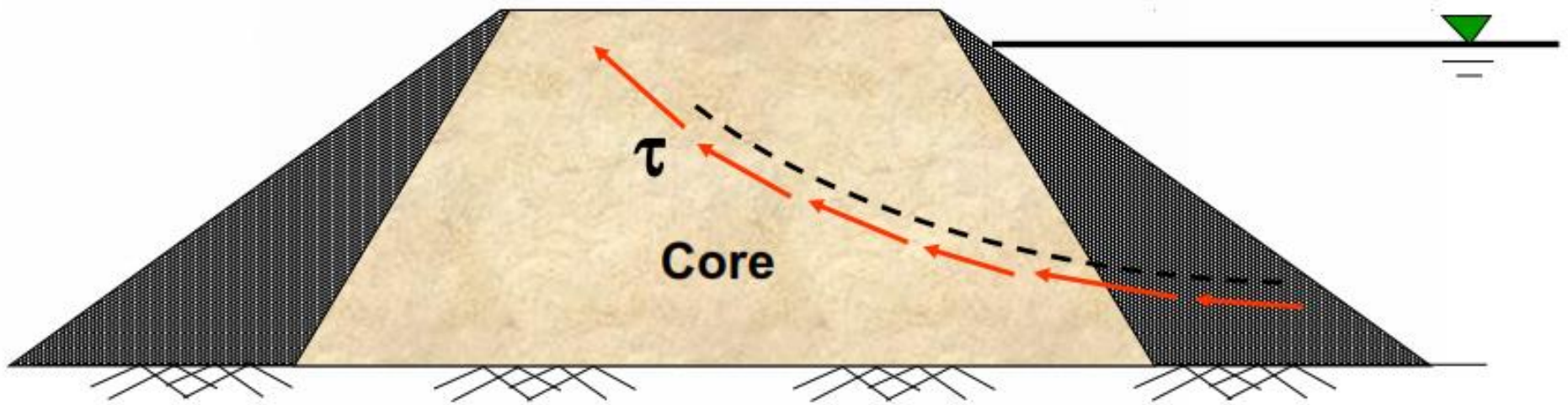
Beberapa contoh penerapan analisis CD pada tanah lempung

1. Embankment constructed rapidly over a soft clay deposit



Beberapa contoh penerapan analisis CD pada tanah lempung

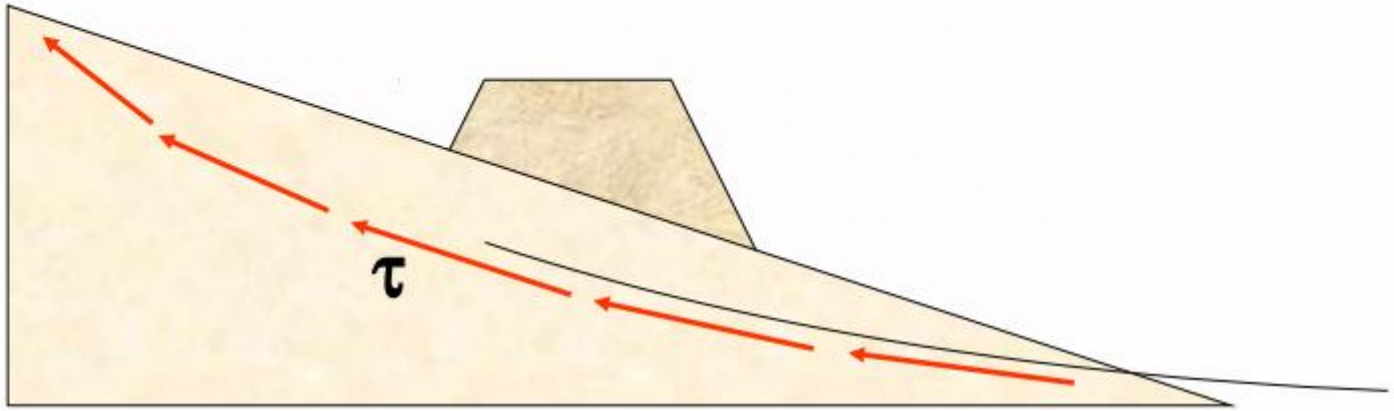
2. Rapid drawdown behind an earth dam



τ = Undrained shear strength of clay core

Beberapa contoh penerapan analisis CD pada tanah lempung

3. Rapid construction of an embankment on a natural slope



τ = In situ undrained shear strength

Note: Total stress parameters from CU test (c_{cu} and ϕ_{cu}) can be used for stability problems where,

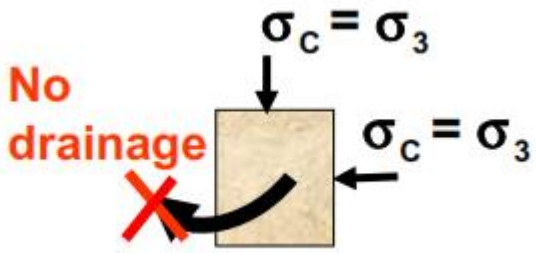
Soil have become fully consolidated and are at equilibrium with the existing stress state; Then for some reason additional stresses are applied quickly with no drainage occurring

Triaxial Test : Unconsolidated Undrained (UU)

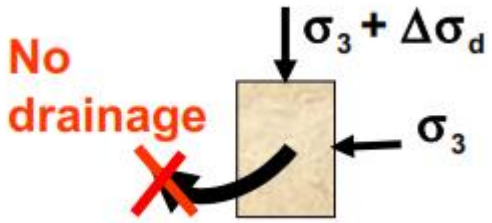
Triaxial Test : Unconsolidated Undrained (UU)

Data analysis

Initial specimen condition



Specimen condition during shearing

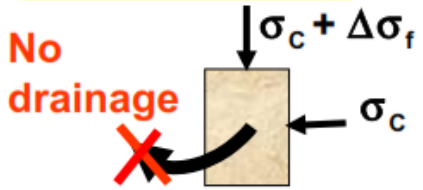


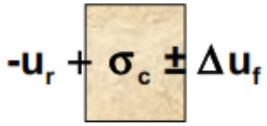
Triaxial Test : Unconsolidated Undrained (UU)

Total, σ = **Neutral, u** + **Effective, σ'**

Step 3: At failure

No drainage





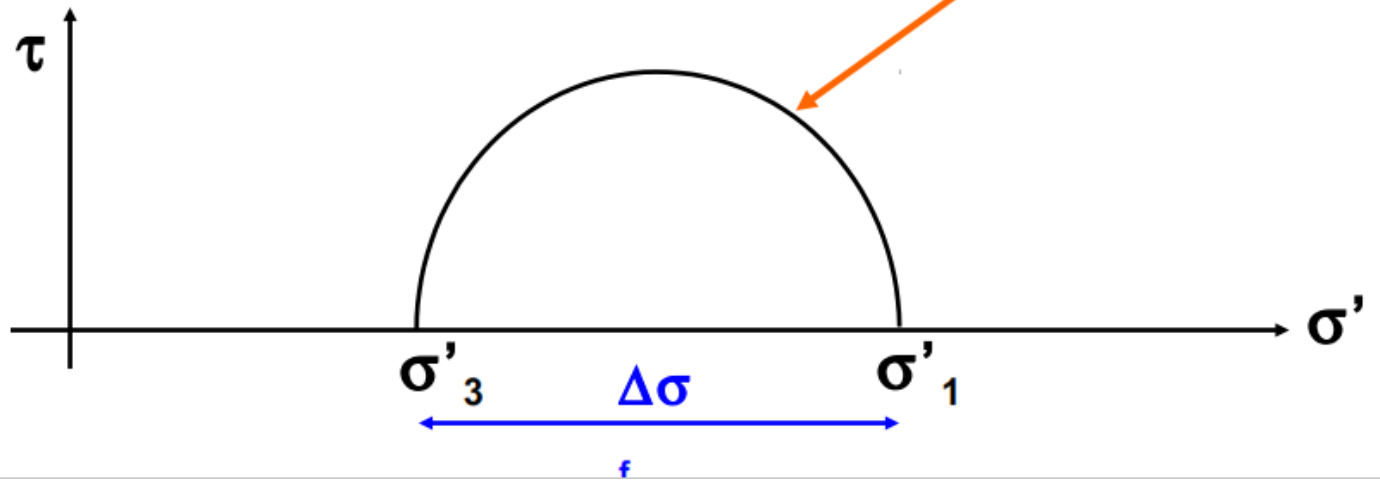
$\sigma'_{Vf} = \sigma_c + \Delta\sigma_f + u_r - \sigma_c \mp \Delta u_f = \sigma'_{1f}$

$\sigma'_{hf} = \sigma_c + u_r - \sigma_c \mp \Delta u_f$

$= \sigma'_{3f}$

Mohr circle in terms of effective stresses do not depend on the cell pressure.

Therefore, we get only one Mohr circle in terms of effective stress for different cell pressures



Triaxial Test : Unconsolidated Undrained (UU)

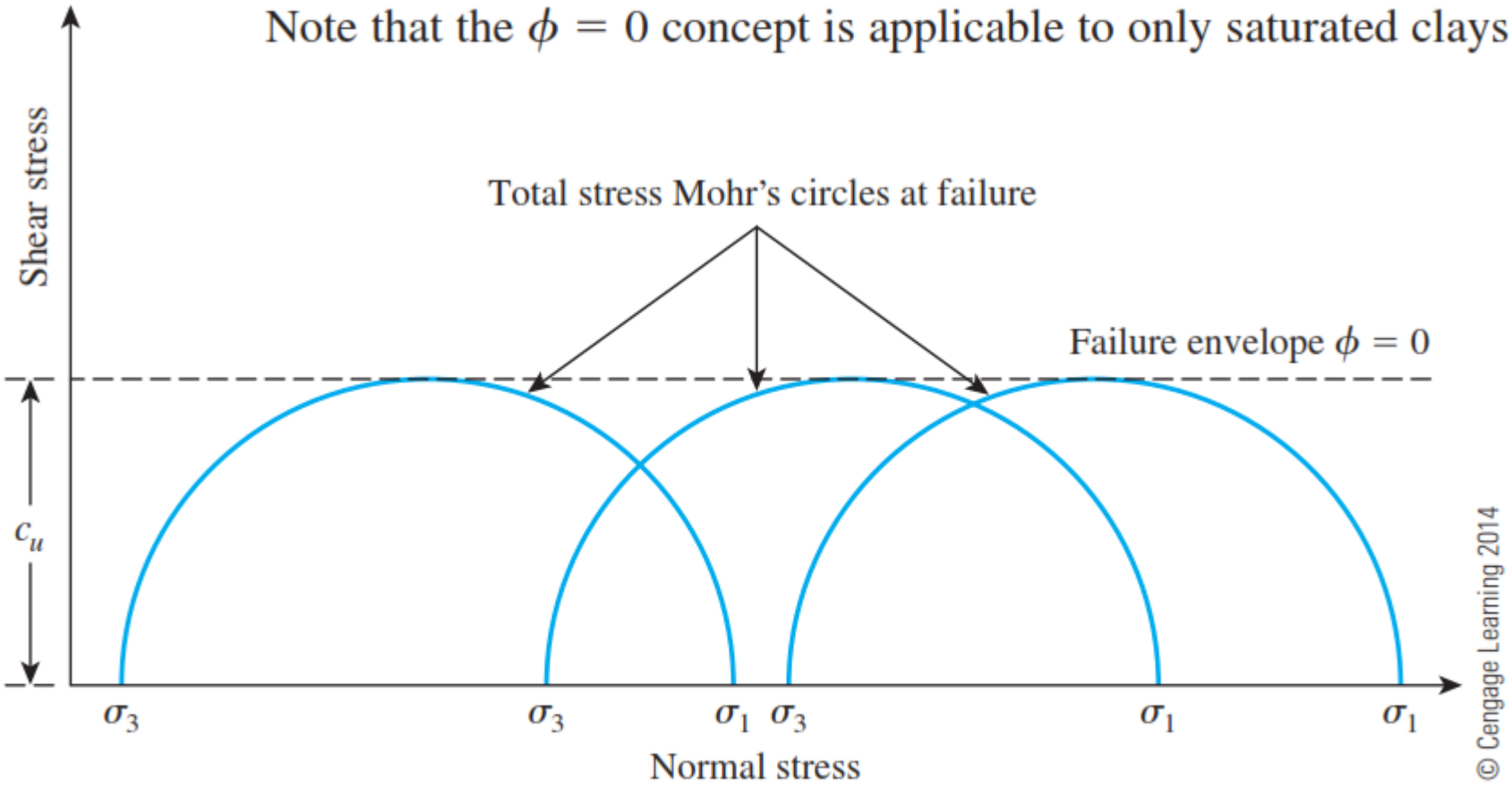
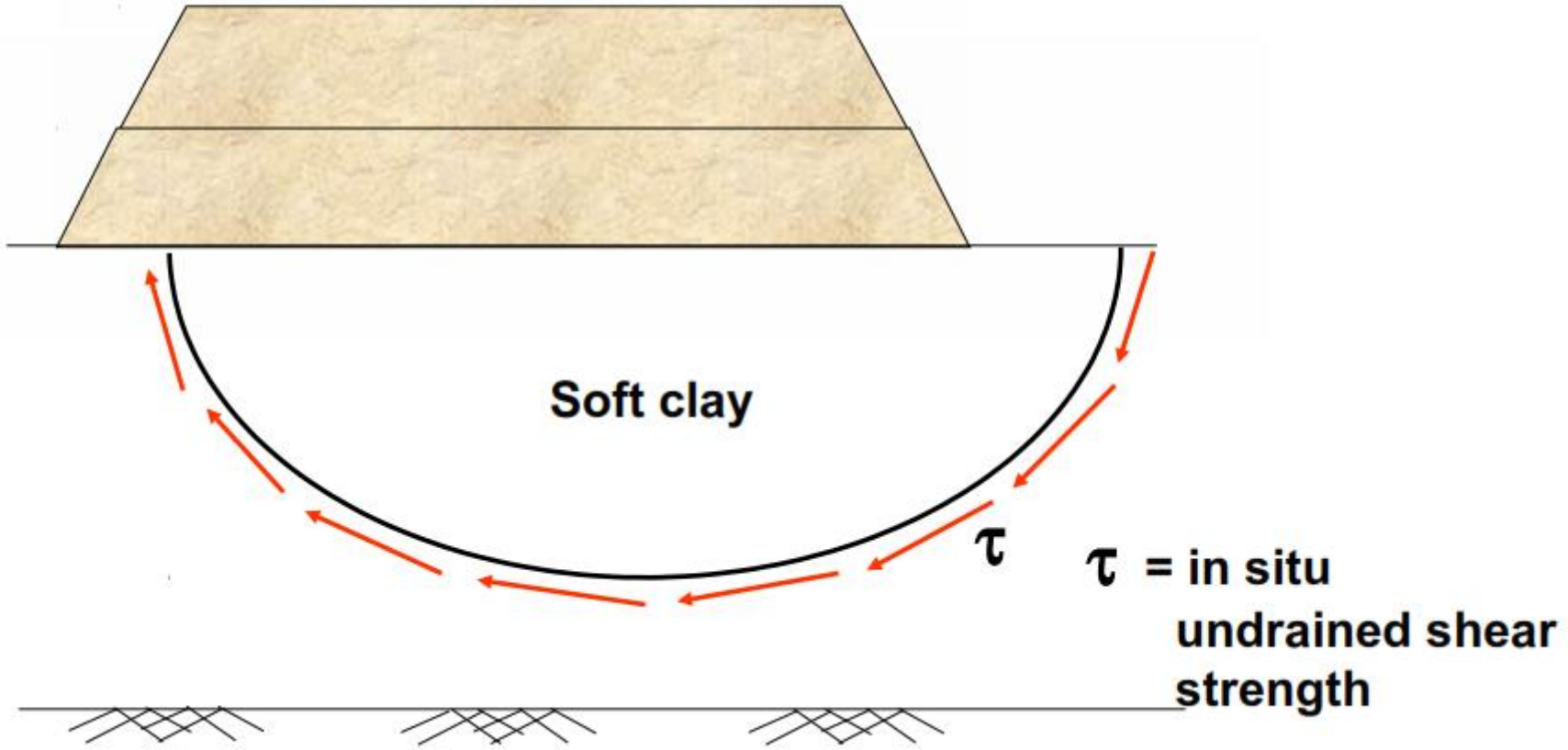


Figure 12.33 Total stress Mohr's circles and failure envelope ($\phi = 0$) obtained from unconsolidated-undrained triaxial tests on fully saturated cohesive soil

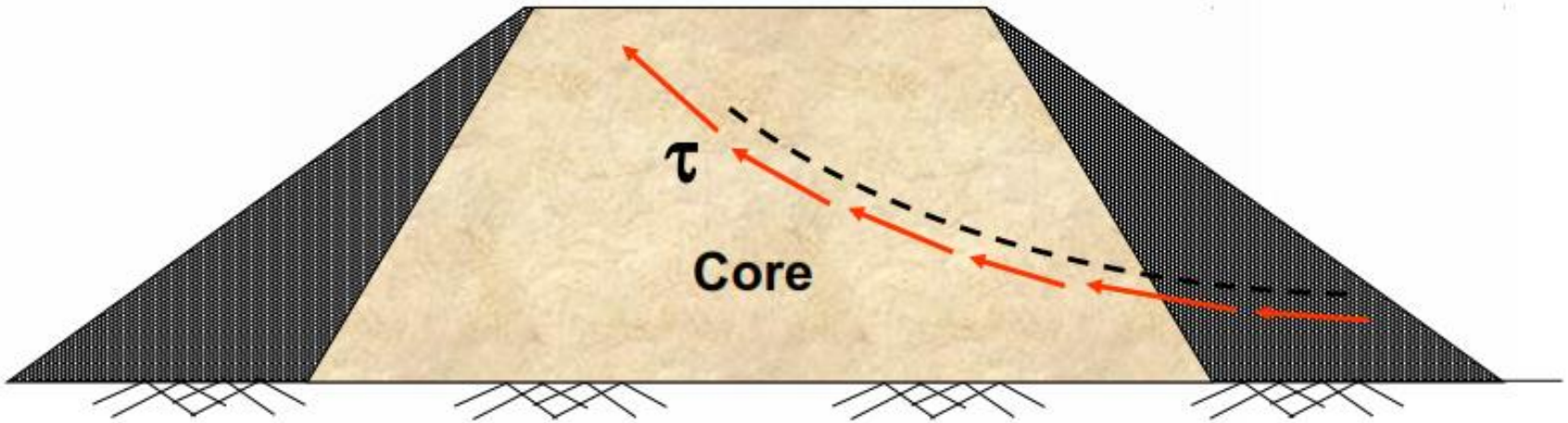
Beberapa contoh penerapan analisis UU pada tanah lempung

1. Embankment constructed rapidly over a soft clay deposit



Beberapa contoh penerapan analisis UU pada tanah lempung

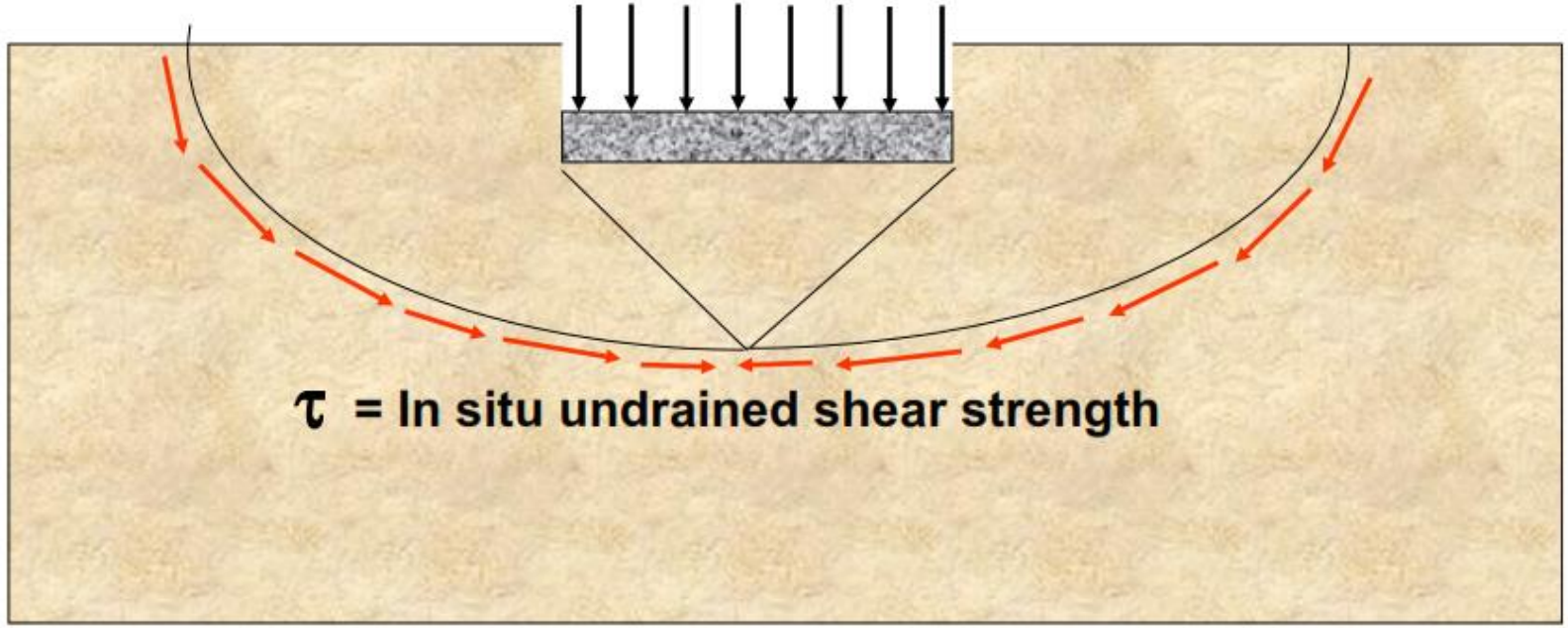
2. Large earth dam constructed rapidly with no change in water content of soft clay



τ = Undrained shear strength of clay core

Beberapa contoh penerapan analisis UU pada tanah lempung

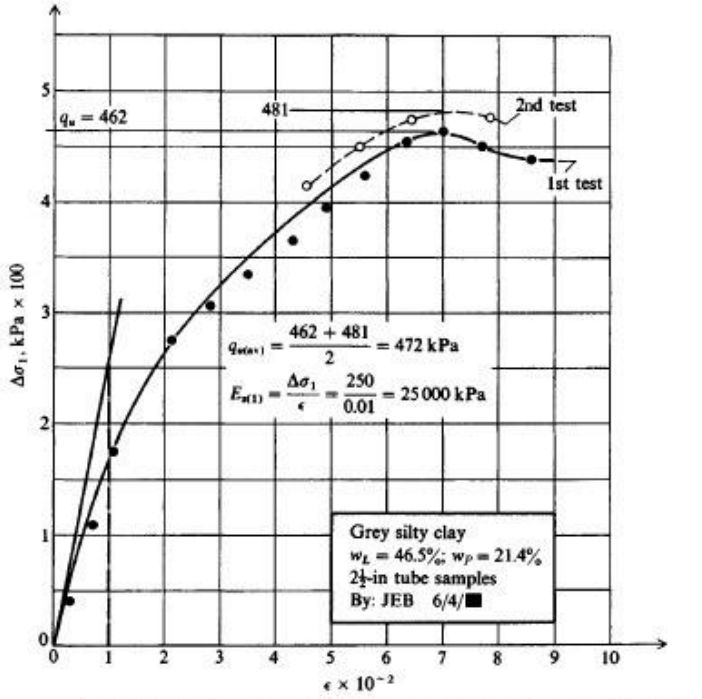
3. Footing placed rapidly on clay deposit



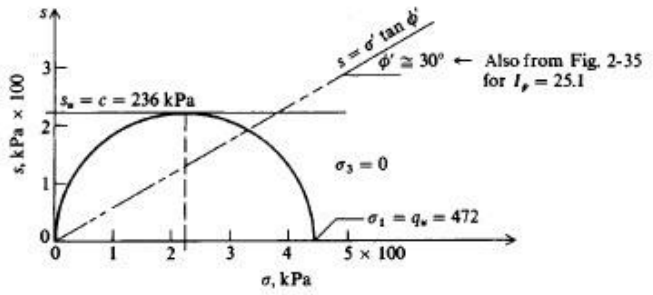
Note: UU test simulates the short term condition in the field. Thus, c_u can be used to analyze the short term behavior of soils

Uji Kuat Tekan Bebas (Unconfined Compression Test

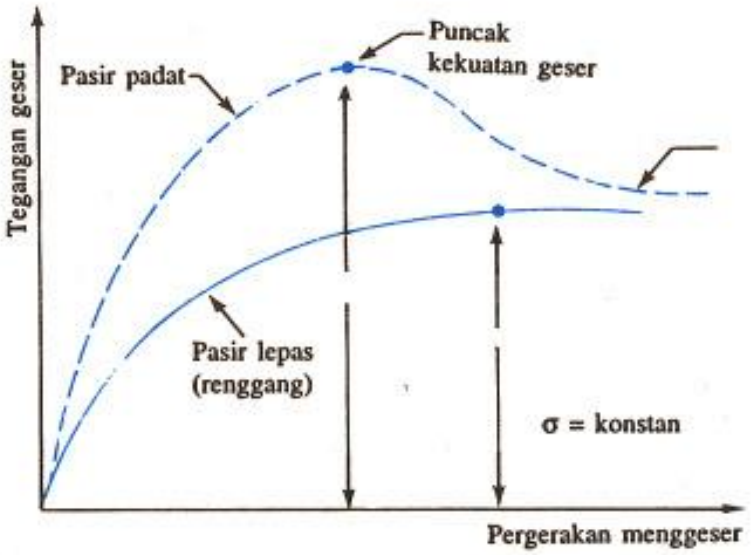
$$\tau_f = \frac{\sigma_1}{2} = \frac{q_u}{2} = c_u$$



(a) Stress-strain plot to obtain q_u. Stress $\Delta\sigma_1$ is computed using equation shown on Fig. 2-23.



(b) Plot of Mohr's circle using **average** q_u from (a) above.



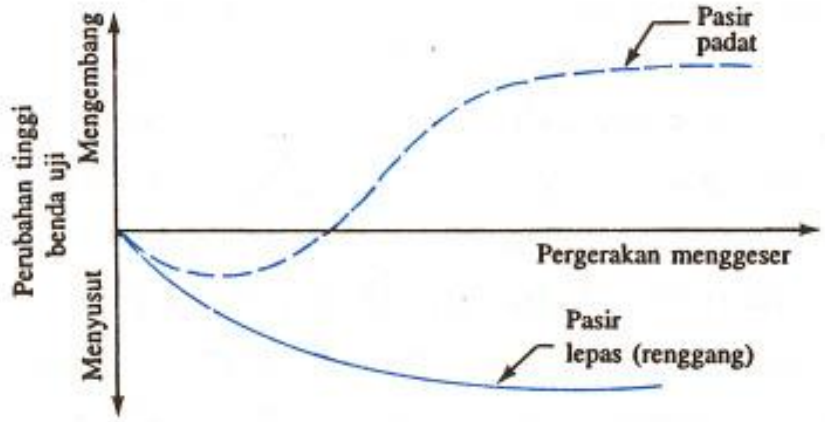


Diagram tegangan geser vs perubahan tinggi, benda uji karena pergerakan menggeser untuk tahan pasir padat dan lepas (uji geser langsung)